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# Science and Gender Relations: The Development of 'Science Identity' of Female Students and Early Career Researchers in Physics and Physical Sciences in Higher Education

by

Ebru Eren

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Supervisor: Aidan Seery

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# Declaration

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# Abstract

Science and Gender Relations: The Development of 'Science Identity' of Female Students and Early Career Researchers in Physics and Physical Sciences in Higher Education

This thesis investigates women's science identity development in physics and the physical sciences in higher education through a gender perspective. It arises from the real-life sociological issue of women's lower level of participation in science in Ireland, especially in physics and physical sciences fields where the gender gap is the highest of all science disciplines, according to the Higher Education Authority in Ireland (HEA) reports of recent years.

Using a case study approach with in-depth interviews this qualitative study aimed to gain a deeper understanding of a gender-science topic through the lived experiences of twenty-nine women from undergraduate to postdoctoral level in physics and physical sciences at four Irish universities in Dublin. It focused on their self-evaluation of science identities in relation to their gender and other social identities, self-identification with science, their expectations, challenges, and attitudes towards the feminist movement in science.

The result of this study demonstrates a variety of possible science identity constitutions of women from an individual and collective identity perspective. This way, the result is expected to guide developing gender-sensitive and diversity-focused educational policies in science at the third level particularly in Ireland where the research takes place. It also aims to promote gender and science dialogue by engaging readers in critical reflections on their own experiences with science.

Keywords: feminism, gender, higher education, physical sciences, science identity, women

# Dedication

I dedicated this study to all women in science, especially to the participants of this study who openheartedly shared their perspectives and lived experiences with me.

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# Chapter 1 : INTRODUCTION

*"Science, it would seem, is not sexless; she is a man, a father, and infected too"*
*Virginia Woolf, Three Guineas, 1938*

## 1.1 Overview

This chapter introduces the research with a focus on the significance of it. Then it presents the objectives of this research and the research questions. It is followed by the researcher's motivation behind this study and a brief introduction of the universities included in this research. It concludes with a summary of each chapter.

## 1.2 Significance of the study

Although more women nowadays are studying for degrees related to science than before, serious barriers remain to the full participation of women in science, and a number of women are lost in science as they climb the carrier ladder, according to the UNESCO Science Report (UNESCO, 2015). At an academic level, women still face biases and barriers at all turns within the scientific community, from publishing, funding, and hiring, to promotion to more senior positions (Grogan, 2019). Especially for the last decade, projects and campaigns have been developed and launched, aimed at empowering women to seek careers in science, increasing awareness about gender equity in science, addressing gender inequalities and biases, introducing gender-sensitive education policies, and improving women's recognition and involvement in science. These attempts to increase diversity and inclusivity in science are inspiring. However, gender inequality continues to exist in the scientific fields, especially for women belonging to marginalized groups (UNESCO, 2018; The Lancet, 2019).

In Ireland where this research took place several important steps were taken to combat gender inequality in science fields. For example, Ireland launched Athena SWAN platform in 2015 to promote and recognise dedication to addressing underrepresentation and promoting the careers of women in STEM research in higher education (Department of Education, 2018). It covers women in academic roles, progression of students into academia and equal working environment for the staff in higher education. Also, the intersectionality working groups was established in 2019 by the nationals Athena SWAN Ireland Committee in accordance with the HEA to eliminate gender and ethnicity inequalities interact in higher education in Ireland (HEA, 2019). Besides, the Institute of Physics which is the professional body for physics in Ireland involved in IOP JUNO programme which aims to establish inclusive working culture and environment in which students and staff can achieve their full potential and raise gender awareness for all staff and students (Institute of Physics, 2017). These are important initiatives to address the underrepresentation of women in physics and physical sciences in Ireland. Most physics and physical sciences schools and departments joined Athena swan and Juno project including the ones that participated in this research project. However, the impact remains a long-term goal as women are underrepresented in physics and physical sciences at every level in Ireland. Especially in the field of physics and physical sciences where my research focused at each stage of the scientific career ladder (from undergraduate to graduate and to a postdoctoral degree) more men than women enrol (HEA 2017/18 Statistics), and more women than men leave the academic science at the highest level (HEA, 2016).

Identifying a problem with women in science is one thing; understanding it is quite another. Science takes place in a social and historical context. Therefore, understanding women's role in science and knowledge from a historical and sociological perspective is crucial. Considering the relations of gender and science in terms of promoting diversity in science is increasingly becoming an important focus of attention. What do women scientists want from science? Do they want gender equality? Harding (1991) has raised an important argument regarding women who make equality statements without offering to question the current social structure or politics of science, as follows:

> Should women want to become just like men in science, as many of these studies appear to assume? To which men in science should women want to be equal? Presumably, the answer is not underpaid and exploited lab technicians or men in racial minorities who have also suffered exclusion and devaluation. (p. 33)

As is clear from her statements, inequality is not only gender-specific but also intersectional which addresses multiple sources of oppression. Anyone who falls outside of social norms may feel this discrimination stronger.

The target population of this research is women in science, particularly female students and early career researchers enrolled in the fields of physics and further physical science disciplines where the gender gap is the highest in Ireland, according to the latest HEA statistics (2017/18). However, I want to note that women as a group are not homogenous, that is to say, "they have very different experiences, perspectives and problematic, depending on variables such as class, country, age, colour or sexuality" (Lederman & Bartsch, 2001, p. 3). Thus, this study deals with women's lived experiences with science under the umbrella of Intersectionality. Although this research has arisen from real-life sociological issues of gender imbalance and underrepresentation of women in science particularly in physics and physical sciences fields, it aimed to challenge the fixed female/male dichotomy and gender roles assigned to this.

Feminist historians of science and women scientists have made significant contributions to the visibility and recognition of women in this field in terms of challenging the gender stereotypes, questioning the androcentric (male-centred) practices in science, making visible and celebrating women's achievements in science (Spongberg et al., 2005; Schiebinger, 2000; 1993).

There is good evidence that women as agents of knowledge have been subordinated throughout the history of modern science (Schiebinger, 1991; 1993). There has been a growing interest especially after the late twentieth century which attempts to uncover and understand women's historic relationship with science. Schiebinger has asked (1993, p. 11) “have women been scientists for a long time and we just do not know about them?” It is not just a matter of counting the number of women scientists throughout history. This question can aid in understanding the current gender and science issues.

Post-feminism takes things a step further by questioning the very nature of womanhood. It does not imply a rejection of women's autonomy or the lack of feminine subjectivity, but rather a consideration of the fluidity and constructive nature of identities outside the gender binary. As argued by Butler (2004), “what falls outside of the norms, strictly speaking, is not recognizable” (p. 5). So, individuals need to be recognized and represented as Butler said, but it is also important to question and challenge the cultural norms by which recognition is conferred. On one hand, feminist politics in science is very important as it allows us to see beneath what are regarded as unjust social orders in science, and to bring women’s voices and perspectives in it. On the other hand, the concept of ‘woman’ identity needs to be critically questioned in order to remove the restrictive and fixed gender boundaries. In this respect, the cultural expectations concerning the gender role of ‘woman’, as well as how it is performed and reproduced, have been extensively explored in this study.

“Science, since people must do it, is a socially embedded (public) activity”, as argued by Sandra Harding (1991, p. 145) which has been constructed by and within power relations in society, not apart from them. She (1991) has claimed that their agendas, concepts, and consequences have been located within particular currents of politics. Similarly, gender is a public action (Butler, 1999) which requires repeated performances, and is socially constructed. According to Butler’s reading of Foucault, our subjective gender identity is created by the regulatory regime of power. Foucault (1982, p. 781) describes the power of individuals and identities as follows:

> This form of power that applies itself to immediate everyday life categorizes the individual, marks him by his own individuality, attaches him to his own identity, imposes a law of truth on him that he must recognize, and others have to recognize in him. It is a form of power that makes individuals subjects

What does it mean to have an identity which power attaches to all of us? According to Butler's interpretation of Foucault (2004), we become attached to ourselves through mediating norms, norms which give us back a sense of who we are, norms which will cultivate our investment in ourselves. For Butler (2004): "in order to be, we might say, we must become recognizable, but to challenge the norms by which recognition is conferred is, in some ways, to risk one's very being, to become questionable in one's ontology, to risk one's very recognizability as a subject" (p. 18).

Based on Foucault's and Butler's arguments, the science identities of women need recognition. However, questioning the norms of recognition, and the theory of power linked with these norms, in Butler's term, can "open the way to live in some less constrained way" (2004, p. 18).

In view of the debates above, when I say 'women in science', I refer to two distinct identity categories- woman and scientist- each of which has its unique political, cultural, social, and economic practices and representations, and each of which has its own attachment to the individuals through social norms. Thus, in order to understand gender imbalance in science with a focus of gender and science identity development of women, firstly I would like to discuss the cultural norms on the construction of gender and science identity along with the culture of science which results in marginalization and suffering to some people while resulting in the privilege to the others.

As noted by Harding (1991), in societies where power is organized hierarchically, the subject of knowledge never simply an individual. It is always an individual with a particular social situation. Not only gender but also race, sexuality, and class elites have control over producing science and knowledge. The solution would not be fitting science to women or fitting women to science. Instead, we will be better able to understand the gender imbalance in science if we question the practices that have excluded certain people from doing science, participating in decision making in science, and seeking and discovering knowledge. In this sense, I appreciate that feminist voices in science in recent years are disrupting this status quo by altering those patterns of scientific authority, raising the women's and minority voices, and discussing the power relations in the production of knowledge and science.

In this study, I examined female students' and early career researchers' self-identification with science focusing specifically on gender identity performance along with other overlapping identities in a small national sample of four public research universities in Dublin, Ireland. Using an identity-based analytic lens allowed me to focus on my participants' perspectives on their views of themselves. I particularly focused on the conflict between the stereotypes associated with a women's role in society, and a woman's perception of herself as a scientist.

## 1.3 Objectives of research and research questions

This research aimed to find out (1) how women in the early stages of their academic careers in physics and physical sciences established and practiced their science identities in relation to their gender identities and other social identities, (2) how they built a sense of belonging to science both individual and collective perspective and how this has affected their academic success and development of their science identity, (3) if they have faced any challenges in these fields along what their coping mechanism were, (4) how they felt about the feminist movement in science and how it influence on their science identity development. To achieve these goals, I asked the following research questions:

1. How do female students and early career researchers in physics and physical sciences fields in higher education construct their science identity related to their gender identity?
2. What are the challenges facing women at the intersection of gender and science identity?
3. Does the women's movement in science influence their science identity development?

Drawing from Feminist, Intersectional, and Queer theory, I explored the construction of a science identity through women's narratives about what it means to be a 'scientist' and how they viewed themselves as 'scientists.' The process of this construction may be complex and sometimes contradictory. Sometimes women may embrace dominant ideas and norms, sometimes they may resist dominant approaches and transform them. Their positioning as 'woman in science' or 'woman doing science' were also examined in order to better understand the impact of gender on the development of their science identities. Their other intersecting identities were also given special consideration.

I then examined how the women participated in this study constructed identities as scientists through their various forms of participation in the practice of science and their individual and collective sense of belonging to science. This study looked at science identity development in undergraduate and graduate schools as well as early-career faculty. In this way, women's science identities could be observed at various academic levels.

## 1.4 Personal motivation and the study context

The story started when I graduated from the Women's Studies Master's programme at Istanbul University in February of 2016.

Having served as a teacher for several years and been trained in gender studies, I was considering starting a project on gender segregation of secondary school students' occupational choices for higher education. The seeds of this plan were actually rooted during my first year of Women's Studies.

I was not a science teacher at that moment, but we used to spend our spare time in class watching science videos and films, which both my students and I loved. When we still had time after the films, we would always open a conversation about what we had just seen. After a while, those conversations evolved to interesting discussions about gender and science. I was amazed to hear their opinions. My students were between the ages of 13 -14, at that time. They were well aware of the gender roles and stereotypes as well as how their future career aspirations are affected by their interest, their competency and the society. As time passed, the focus turned to scientific careers. During our conversations, I became more aware of my students' gendered educational choices, future job aspirations, and how they viewed science.

At first, I prepared a thesis proposal that focused on girls' science identity development and their gendered paths into science. Later, the target population shifted from girls in lower secondary level education to women in third-level higher education when I met my supervisor from Trinity College Dublin. First and foremost, his area of expertise was higher education. Second, since I would not be a teacher in Ireland, it would take a lot of time to become proficient in the first and second level education system, as well as how to gain legal permission to reach girls under the age of 18. In addition, I had no idea which schools could be included or how to contact them. According to what I have heard from people, the school systems of Ireland and Turkey are vastly different. There are two tiers of education in Ireland: primary and secondary level of education. In Turkey, there are three tiers of education: primary, post-primary (lower secondary), and secondary. I worked as a post-primary school teacher. In Ireland, students mostly choose their profession after finishing secondary school and receiving their leaving certificate, but in Turkey, they do so as early as post-primary school, as there are various types of secondary school (high school) depending on the students' potential career goals. To keep it simple and straightforward, I wanted to collect data from women who were studying and working in science fields in higher education.

I started to read the statistics reports of HEA of Ireland about new entrants, enrolments, and graduates by field of study and gender at higher education institutes. According to these reports among all science disciplines, physics and further physical sciences have the highest gender imbalance. As a result, I described the target demographic as "women studying and working in the fields of physics and physical science at all levels, from undergraduate to postdoctoral." The next step was to decide which universities would be included in the study and how many people would be interviewed.

At the time, there were three major research-intensive universities in science fields in Dublin: Trinity College Dublin, Dublin City University, and University College Dublin. I decided to include them all because they each have their own special characteristics and status. Trinity College Dublin is the oldest and top-ranked university of Ireland. Dublin City University is a relatively new university that is collaborating with the business. University College Dublin is Ireland’s largest university and has a modern campus and vision. On the suggestion of my supervisor and the reader of my Ph.D. confirmation papers, I included Technological University Dublin in the second semester of my second year. The university’s primary focus is on STEM subjects. It was made up of the Dublin Institute of Technology, the Institute of Technology Blanchardstown, and the Institute of Technology Tallaght. It is the first technological university in Ireland.

The universities I selected all have their own distinct strengths and perspectives, as well as different establishment purposes, which I thought would provide me with a diverse sample.

The following faculties and research centres responded to my interview recruiting call:

**Trinity College Dublin** School of Physics, CRANN Research Institute, AMBER Centre, IGRAC Research Centre.

**University College Dublin** School of Physics

**Dublin City University** School of Physical Sciences

**Technological University Dublin** School of Physics & Clinical & Optometric Sciences, FOCAS Research Institute

The data were generated through 29 interviews. The participants were women from the above-mentioned faculties and research centres who studied and worked in various subfields of physics and physical sciences

When I look back to those days from my teaching years to the end of Ph.D., I am grateful to my students, my colleagues, friends, and lecturers from the Women's Studies, my Ph.D. supervisor, and the women participated in this study for moving this research forward by sharing their experiences, views, suggestions, and support.

## 1.5 Structure of the thesis

I outline the individual chapters of this study in this final part of the introduction. There are seven chapters of this thesis.

To begin, in chapter 1, the research is introduced and situated, the research goals and research questions are presented, and the motivation for this research is clarified.

Chapter 2 and Chapter 3 reviews the literature on science and gender. Chapter 2 focuses the literature on women's historical relationship with science and knowledge, feminist criticism of science, gender stereotypes and bias in science, the masculine culture of physics and physical sciences, and women's challenges within these academic fields. This chapter concludes by presenting the model of the science identity framework used in this study. It also reviews some of the relevant literature addressing how science identity is conceptualized.

Chapter 3 provides an in-depth discussion of feminism, intersectionality, and queer theory which constitutes the backbone of this study. These theories guide the research from the beginning to the end. In this chapter, within the feminism section, a particular focus is given to ‘women’ as a gender category, women’s individual and collective identities, and attitudes towards ‘feminist’ labelling. This is followed by discussing differences between women and concludes with explaining gender performativity. By discussing gender and science from a historical, sociological, and critical perspective, Chapter 2 and Chapter 3 aim to underpin the discussions of dynamism of gender and science identities of women which are analysed and interpreted in the following chapters.

Chapter 4 discusses the methodological choices and research design of this research. This chapter details the methods used and the process of analysis leading to the findings presented in Chapters 5 and 6. Chapter 4 also includes the researcher’s background, researcher’s position and reflexivity, challenges in the analysis, interpretation and representation stages, ethical consideration, and methodological limitations. This chapter further discusses the relevance of a feminist, intersectional, and queer understanding of gender and science identities, as well as the theoretical basis for these ideas in the study process.

In Chapters 5 and 6 the outcomes of the analysis of the interviews are presented. I begin the presentation of my theoretical results in Chapter 5 with women's narratives. It contains participant bios, and findings.

In Chapter 6 the findings are interpreted and discussed in the light of relevant literature and a theoretical framework. The distinction between Chapter 5 and 6 is that the former includes predominantly women’s voices while the latter focuses on my interpretation of the narratives.

The final chapter continues with a discussion of recommendations for further research and for Irish higher education faculty and practitioners in physical sciences fields. This chapter concludes with a summary of key findings and concluding remarks.

The thesis also includes the bibliography and appendix section which contains interview questions, ethnic approval form, participant consent forms, interview recruitment e-mails, a personalized e-mail example, a google form, participant recruitment poster, and examples of interview scrip.

# Chapter2 : LITERATURE REVIEW - DOING SCIENCE-

## 2.1 Overview

In the first section of this chapter, I present a brief historical background of women's places in science and knowledge from the emergence of modern science until the rise of feminism in the late nineteenth and early twentieth century. The section particularly addresses gender dualism and how dualistic thinking influenced people's conceptions of knowledge, knowers, and practices of science.

In the second section, I explain how the feminist movement sheds light on the women's experiences, their contribution to science and knowledge, and how dualistic thought was challenged from a feminist perspective. This section comprises of a subsection which further discusses Subject/object dichotomy and women's entering the scene as 'knowers.'

Following is the third section that focuses on gender stereotypes and bias in science and their effect on women's and girls' performance, aspirations, and progression in science by presenting different studies specifically addresses the effect of stereotypes on women's science identity.

The next section discusses further gender disparity in physics and certain physical science domains. This section also reviews some of the relevant literature that focuses on these two disciplines which are viewed as 'hard' and 'masculine'.

The chapter concludes by explaining science identity and physics identity construction both in the context of this study and referring to other similar studies done before.

My argument is that to fully understand the gender and diversity problem in science, we need to go beneath the surface of appearances created by an unjust social order and to see the roots of the problem from historical and sociological perspectives. By and large, this chapter can give the readers a critical understanding of the factors behind women's underrepresentation in science.

## 2.2 Historical overview of women's relationship with science and knowledge

*"Of what a strange nature is knowledge!*
*It clings to the mind when it has once seized on it like a lichen on the rock."*
*Frankenstein by Mary Shelley*

Western philosophy has been built around the idea of binary oppositions such as female/male, body/mind, emotion/reason, private/public, nature/culture, subjective/objective. The dualistic thinking, almost always in history, has led to the association of maleness with reason, mind, objectivity, culture, and the public while femaleness is associated with emotion, body, subjectivity, nature, and private. For Bacon, who is thought to be the founder of modern science, the only knowledge of importance to humans is empirically rooted in the natural world, and truth requires evidence from the real world. Thus, the mind's task in knowledge started at this time as the control of nature. The theme of the dominance of the soul over the body in Ancient Greece was developed into the dominance of mind over nature in Baconian science and knowledge.

Sandra Harding (1986) argued that sexual metaphors played an important role in the development of science. Similarly, Evelyn Fox Keller in her interview with Bill Moyer in 1990 pointed out that the ideas of masculinity, ideas of femininity, that the language of sex and the language of gender have been extremely prominent in scientific discourse since the scientific revolution. According to her (1990,) the development of modern science cannot be properly understood "without attending to the role played by metaphors of gender in the formation of the particular set of values, aims, and goals embodied in the scientific enterprise" (p. 43). Mary Shelly was maybe one of the first to understand the danger of sexist metaphors in science in those days of the Scientific Revolution and illustrated this in her book *Frankenstein.* In *Frankenstein,* Victor who is depicted as a cold scientist in the sense of pursuit of knowledge loses himself in his scientific experiment and creates a monster, which in the end, makes him feel lifeless. At its core, the book shows the consequences when science confronts and breaches the limits of nature.

The distinction between mind and body which implies between reason and its opposite became sharper in Descartes' philosophy which largely became known as 'Cartesian dualism'. Mind and matter were separated into two different substances. Descartes' quote "I think therefore I am" is primary of mind in self-knowledge.

As stated by Lennon (2010) the dualism of reason/emotion has become embedded in the mind/body dualism, with reason associated with the mind, and emotion with the body (often seen as 'irrational'), and the dualism of masculinity/femininity, with the mind viewed to be masculine and the body regarded to be feminine. Thus, Descartes' thought, unintentionally, provided "a basis for a sexual division of mental labour whose influence is still very much with us" (Lloyd, 1984, p. 49). While women's predominant role has been regarded as childrearing and domestic labor which refers to their biological destiny (Satz, 2017), men have been viewed as mainly involved in "income-earning" practices. (Hakim, 1996, p. 179). Okin (1979) explains this as follows:

> *While man has been categorized in terms of the generally limitless potential for rational thought, creativity, and so on, woman has been viewed as functionally determined by her reproductive role and her actual and potential abilities perceived as stunted, accordance with what has been regarded as the requirements of this role (p. 99).*

The division of the gender roles is also quite visible in Rousseau's *Emile* in which he describes the education of Emile and his female counterpart, Sophie. According to Rousseau, in his book *Emile* (2009), men and women think and reason differently.

> *The search for abstract and speculative truths, for principles and axioms in science, for all that tends to wide generalization, is beyond a woman's grasp; their studies should be practical. It is their business to apply the principles discovered by men, it is their place to make the observations which lead men to discover those principles (p. 774).*

Such a sharp gender distinction based on sexuality in Rousseau's philosophy led to gendered social roles in the public and the private sphere. Women's roles were strictly confined to domestic work in the private sphere while men gained access to knowledge and science which is thought to have been in the public sphere. Criticizing Rousseau and similar essentialist ideas on women, Mary Wollstonecraft (1989) asked if it was nature or society that determined the characteristics of women, kept them out of the public sphere, and avoided them producing the knowledge:

> …either nature has made a great difference between man and man, or that the civilization, which has hitherto taken place in the world, has been very partial (p. 73).

From Aristotle to Rousseau, a woman's nature unlike man's is defined in terms of its sexual reproductive functions. While man has been identified with rational thought, woman has been determined by her reproductive role. Kant also supports the idea of equal but different. Equal here means complementing each other rather than holding equal positions in all walks of life. As pointed out by Llyod (1984) the male is taken as a norm in Kant's philosophy.

Hegel, like Kant, emphasizes "female" virtues as docile, nurturing, modest and kind. Blum (1982) in his essay on Kant's and Hegel's moral rationalism states that "in a male-dominated society, the qualities of character attributed to women are naturally seen as less significant than those of men" (p. 296). So, it is not surprising that in the eighteenth century around the industrial revolution and scientific revolution science and philosophy were parts of a terrain that fell to the male sex.

As claimed by Schiebinger (1993, p. 17), “if science has come to mean objectivity, reason, dispassion, and power, femininity has come to mean everything that science is not: subjectivity, feeling, passion, and impotence.” This predominant mode of thought about women since Ancient Greek which was at its peak in the Enlightenment period has continued in modern times which has strongly affected the discussion of the status of women in the society.

The nineteenth century, especially towards the end of the century, witnessed a strong feminist movement which had a huge impact on the rising of women as a “subject (agent)” rather than “object” of knowledge and science. After the mid-nineteenth century, the women's movement invited more women into the so-called "men's world." However, the whole thought system was still based on binaries that subordinated women. For example, in the mid-nineteen century, social Darwinists invoked evolutionary biology to argue that a “woman was a man whose evolution- both physical and mental- had been arrested in a primitive stage” (Schiebinger, 1993, p. 16).

A similar thought was visible years later in Freud’s ideas on women which resulted that gender binary was reinforced, and female sexuality and femininity were pathologized which reinforced women’s inferior status in society. Women and their wants and needs were again determined by her sexual characteristics. The old myth of women as naturally inferior, less rational, and more emotional was regarded as good evidence in the rise of psychiatry and psychoanalysis as medical science.

Emilie du Chalet, eighteenth-century natural philosopher, mathematician, and physicist, asked (2009a, p. 49): “why is it that for so many centuries not a single good tragedy, fine poem, valued story, beautiful painting, or a good book on physics has been produced by the hand of a woman?” The same question has occupied my mind for a long time since I started to investigate female scientists in the past. Were they invisible, mis/underrepresented, or were they totally absent? Why has knowledge been long since in the hands of male humans by a majority? The culture of philosophy and science has not only male-centred, but also Eurocentric and Western, White-dominated and privileged mostly for the upper class. Also, thinking objectively has long been regarded to be thinking like a man.

The story has long been constructed from the perspective of those who have dominated the knowledge both politically, socially, and economically. Why do not we construct the story from the perspective of those who resist oppression? To do so, it is important to speak out on the perspectives of minority communities and to publicly address what it is like to be a woman, a black person, or a transgender person (or some other identities that has been branded as "Other") and a scientist.

Keller (2001) argued that being a female scientist, she actually came to see the story (the effect of doing science as a woman) “as public, that’s of political significance rather than simply as private, of merely personal significance” (p. 60). Relevant to this statement, if we get back to Emilie du Chalet’s question, perhaps there were significant female scientist and philosophers in the past, but their stories have not been remembered or perhaps, as suggested by Schiebinger (1991, p. 2) “women have dominated certain fields but these fields have not been recognized as science” (e.g. midwifery).

What gender was science as an activity and set of ideas then while the scientists were overwhelmingly male? Schiebinger (1991) pointed out that when the personification in the art flourished from the thirteenth to sometime in the late eighteenth century physical “science was portrayed as a goddess with a terrestrial globe at her feet, geometry was a woman holding a plumb line and compass, astrology, too, was a woman dressed in blue and wearing a crown of stars and wings signifying the elevation of her thoughts to the distant stars” (p. 122). She (1991) further noted that feminine icon was used to describe science during the Renaissance period, and the feminine image of science remained strong long into the eighteenth century. It is interesting that while the images were female in describing science, the artists and scientists were all males. Schiebinger has explained the gender in the art in connection with gender division in language.

The late eighteenth century saw the decline of the feminine icon in scientific culture. During the 1800s explicit images of science are replaced by implicit and popular "images of a scientist as an effective male, working in a modern lab, most often wearing a white lab coat" (Schiebinger, 1991, p. 148). Feminine icons represented in science do not justify the female presence in science even those days. Although there were a few women philosophers and scientists before the twentieth century, they have not been presented in history as much as male counterparts. Their struggles to make a mark in science have not even been valued today. It is neither the softness and coldness of the female brain that was given evidence around the sixteenth-seventeenth century for the absence/underrepresentation of women in science nor female sex/gender which has confined women to heart and home as if their sex was their inevitable destiny as mothers, wives, carers. It is the reflection of a misogynistic social, cultural, and ideological patterns imprinted into the very structure of the society.

As feminist theory appeared in the mid-twentieth century, topics such as the subject (agent) of knowledge and male appropriation of knowledge were reintroduced and re-debated in order to be transformed. Moreover, the maleness of reason as well as gendered values was challenged. In the following section, it was addressed in greater detail.

As a researcher, I feel it is important to address topics in the light of their historical and social backgrounds in order to grasp current debates. Shedding light on the roots of this inequality and the efforts of women scientists in the past may help to add historical understanding to the problems of gender and science facing us today.

My thesis aims to better explain the development of women's science identities from a gender perspective. The historical background of women's relationship with science presented in this section, as well as the next section gave me a wider perspective on the roots of women's science identity development. In this study, women's science identity is presented as a 'becoming' process with a close link to the past and present. Before looking at women's science identity development through lived experiences of the participants in this study, both this and the next section intended to show the readers and myself under the surface of what is currently being discussed in terms of women's collective science identity construction, agency and positioning in science.

## 2.3 Feminist reflections on science and knowledge

*"The ultimate descriptive task, for both artists and scientists, is to 'ensoul' what one sees, to attribute to it the life one shares with it; one learns by identification."*
*The Life and Work of Barbara McClintock by Evelyn Fox Keller, 1984*

The feminist movement in the twentieth century brought a new perspective on the theory of knowledge, scientific and epistemological investigations, the knowing subject, women's experiences, and their struggle in the public sphere. Especially from the beginning of Enlightenment, in Western philosophy, "dichotomies work to establish the features of ideal, universally valid knowledge as a product of strictly rational endeavour, and to separate it from opinion, hearsay, particularity, which are associated with (stereotypical) femininity" (Code, 2007, p. 213).

When it comes to gender and science, I agree with Keller (1985) that the issue is not woman or man as a "single stable gender identity," but the "making" of woman or man as a social structure, role divisions, a cultural practice, and a binary gender ideology, and how this "making" influences how we do science, how we are represented in science, and how visible we are to science.

> *Science is the name we give to a set of practices and a body of knowledge delineated by a community, not simply defined by the exigencies of logical proof and experimental verification. Similarly, masculine and feminine are categories defined by a culture. Women, men, and science are created, together, out of the complex dynamic of interwoven cognitive, emotional, and social forces. My subject is, therefore, is not women per se, or even women and science, more precisely, how the making of men and women has affected the making of science (p.4).*

A feminine perspective of science, according to Keller (1985, p.8) confronts us with the task of examining the roots, dynamics, and consequences of this interacting network of associations and disjunctions- together constituting what might be called the "science and gender system". As a woman scientist, a mathematical biophysics specialist, Keller has tried to determine how the ideology of gender has affected the making of science.

Especially since the early 1980s, feminist epistemologists and philosophers of science have been engaged in debates about the philosophical conception of epistemic agency, justification, reason, objectivity, and scientific knowledge. They have also drawn significant attention to subjectivity, values, evidence, relativism, power, recognition, credibility, and trust. They have adopted different approaches to women's questions in science and knowledge.

Feminist empiricists assert that "empiricism committed to objective evidence-gathering and justification, informed by feminist ideology could produce more adequate knowledge than classical empiricism" (Code, 2014, p. 11). As feminism has a political agenda, feminist empiricism has undoubtedly feminist values at the core of its theory. So, it rejects the view that science is value-free. If science is considered to be objective which is identified with taking the standpoint of a neutral observer, Campbell (1994) has asked if one can be both neutral and politically committed. He states that this, according to many feminists, is a reason for rejecting feminist empiricism.

According to the feminist standpoint theory, knowledge is a socially situated and human activity just like science is. Since they are outsiders within, marginalized groups can be more aware of things more than non-marginalized ones, so they can reach more objective results. Because, knowledge produced in a subordinated and marginalized group, as Collins (2000) notes, can foster resistance to hegemonic norms while producing knowledge good for its kind.

Both standpoint theory's calling attention to women's lived experiences of oppression as the starting point for building knowledge, and feminist empiricism's commitment to uncovering androcentric bias by encouraging the practice of 'good' – feminist science has contributed the women's access and representation in science, as well as producing scientific knowledge. However, neither empiricism nor standpoint theorists succeed in resolving 'gender issues' in science and epistemology. According to Code (2014), empiricists were unable to fully address the power-saturated circumstance of diversely located knowers. Nor in the absence of unified feminism, could standpoint theorists avoid obliterating differences.

"Feminism loves another science", says Donna Haraway (1988, p. 589). What kind of science does feminism love? For her, it is the science with multiple subjects with at least a double vision. She argues that there is no single feminist standpoint because our maps require too many dimensions for that metaphor to ground our visions. She offers the metaphor of (double) vision – like a double-edged sword to discuss situated knowledge. It means that individuals always see through a particular position and a particular body. So, for her, as a standpoint theorist, rational knowledge is from everywhere and so nowhere. Haraway (1988) sums up her theory as follows:

> *I am arguing for politics and epistemologies of location, positioning, and situating, where partiality and not universality is the condition of being heard to make rational knowledge claims. These are claims on people's lives. I am arguing for the view from a body, always a complex, contradictory, structuring, and structured body, versus the view from above, from nowhere, from simplicity... Feminism loves*

*another science: the sciences and politics of interpretation, translation, stuttering, and the partly understood (p. 589).*

If science wants multiple subjects with double vision and if partiality is necessary to make rational knowledge, how can we distinguish among women and reach a consensus if each standpoint is unique? Longino (1996) claims that women occupy many social locations in a racially and economically stratified society. If genuine or better knowledge depends on the correct or a more correct standpoint, social theory is needed to ascertain which of these locations is the epistemologically privileged one. According to Longino's feminist social theory (1996) "what gets produced and knowledge depends on the consensus reached in the scientific community" (p. 278).

For knowledge to count as genuine, the community must be adequately diverse, but the demand for inclusiveness should not be taken to mean that every alternative view is equally deserving of attention. Discussion must be conducted in reference to public standards, "standards that do not provide timeless criteria, but which change in response to changes in cognitive and social needs" (Longoni, 1996, p. 223). I agree with Longino's argument that if science is based on a true knowledge reached by consensus or justified by a scientific community, giving privilege always to the less powerful ones may result in conflict. If it is a consensus, "there should be interactive dialog among the community, but it should not be at the cost of quieting critical oppositional positions" (Longino, 1996, p. 274).

From a post-structuralist point of view, there is no absolute truth or essential reality that knowledge is based. For instance, Hekman (1997) argues that there may be no truth about social totality to be discovered. But she (1997) has added that this does not mean that the systemic analysis of the institutions of patriarchy is necessarily precluded. She (1997) argues that women speak from multiple standpoints, producing multiple knowledge. But this does not prevent women from coming together to work for specific political goals- a political goal that patriarch must be eliminated. She explains how postmodern feminism differs from both empiricism and standpoint theory as follows: (1990):

> *Postmodern feminism would reject the masculinist bias of rationalism but would not attempt to replace it with feminist bias. Rather it would take the position that there is not one (masculine) truth, rather many truths, none of which is privileged along gendered lines (p. 9).*

From a feminist poststructuralist view, knowledge which was defined as justified true belief came to be understood as “power” (Keller, 1987, p. 11), as “the power to dominate nature with the rise of modern science”. In the case of science, Keller further claimed (1987) that the construction of gender as the construction of exclusion of women, of the feminine, of simultaneously of the alternative meanings of power that knowledge might engender. From this perspective, the most central issue is gender, science, and power. Thus, neither different science or feminine science nor is a separate different reality is a matter of poststructuralism. To expect women, scientists, to embrace the concept of a different science (feminine science), according to Keller (1987), would be to ask them to give up their identity as scientists, much as traditional science has asked them to give up their identity as women. So, neither homogenous nor divided, but a wider representative, richer and multi-dimensional landscape is a prerequisite for knowledge in science.

Working from a feminist poststructuralist perspective I claim that an individual can be comprised of several “possible selves located in different story-lines” (Sowell, 2004, p. 44). Thus, women’s science identity, which is the focus of this study, is conceptualised ‘flexible’, ‘becoming’, and ‘constantly unfinished entity’. As stated before, both feminist empiricism and feminist standpoint theory require a stable ‘woman’ subject However, in this research, what it means to be a woman changes over time and place, as well as being subjective and situational.

### 2.3.1 Women as ‘knowers/agents’ of science

In the late twentieth century, feminist philosophy emerged as a distinctive field. Feminist theorists began to ask “why, and how, have women all over the world been epistemologically dis-authorized as knowers” (Alcoff & Kittay, 2007, p. 11).

As noted earlier, while rational knowledge has long been based on the lives of men in the public sphere, “the feminine has been associated with what rational knowledge transcends, dominates or simply leaves behind” (Llyod, 1996, p. 41). Therefore, it is not surprising that Marie Curie was rejected for membership in the Academie des Sciences in France in 1911 when she won her second Nobel Prize. Similarly, even though The Royal Society, the world's oldest independent scientific academy, was founded in 1660, women were not permitted to become fellows of the Royal Society until 1945. Even worse, it was just a few years ago when Nobel Prize scientist Tim Hunt (2015) said that female scientists cause trouble for men in labs.

This mind-set which has given privileges to men for producing and controlling the knowledge has resulted in gendered knowledge and a gendered division of social roles that have led to the marginalization of women in ‘male-dominated’ areas which of them is science. Not only have women been excluded from male-dominated areas, but other Others (from a White male norm), as argued by Code (2007), both female and male, have been judged variously incapable of the reasoning from which alone valid knowledge is derived from.

Reason and rationality are regarded as prerequisites for science and scientific knowledge. In Western philosophy which has a hierarchical division between rational and irrational, “only people who can claim or -are accorded- a place within the rational can expect the acknowledgment and respect and the entitlement to social-political epistemic authority" (Code, 2007, p. 212). Especially after the

Enlightenment, the man of reason has been the man of science. It is so deeply embedded in our minds that I could not agree more what Code (2014) says in her article that the subject S, in the standard S-knows that- p formula in which propositional knowledge claims are ordinarily stated, is presumptively male to the extent that there is no need even to mention his maleness. In this circumstance, if this 'S' is Sam, let us say, Sam knows that the tree is green, then the sex of the knower, as stated by Code (2014) would be regarded as "being of no greater significance than the size of his feet" (p. 10). But the sex of the knower is epistemologically significant if it is not within the norms. So, if this 'S' as someone not male, not white, not western, not any other stereotypical individual, his/her identity as a knower would matter. Because, "standard-setting knowledge in western societies mostly derives from the experiences of white, middle/upper-class educated men" (Code, 2014, p. 11).

In this case, what does feminism require from knowledge, and how does it situate the knower? What has feminism done to challenge the stereotypical 'White, middle/upper-class man' as a knower /agent of science? What does feminism suggest in order to open a new space for a multiple of knowers in science? Would gender bias in science and masculine way of knowing to disappear when we add the experiences and perspectives of women? I claim that it would be a failure to add the female perspective to the inadequate and incomplete male perspective of knowledge. If feminism is to be successful, it must begin by "attacking and displacing the masculine/feminine hierarchy at the root of the western episteme" (Hekman, 1990, p. 26).

## 2.4 Gender Stereotypes and bias in science

*"We are failing by not giving young women the self-confidence to think that they can be scientists."*

*Vera Rubin, Bright Galaxies, Dark Matters, 1997*

There is also a wide body of research on gender stereotypes in science. Most of these studies have focused on the negative stereotype effect on women's performance, ability, science identification, and their academic self-concept in STEM fields. (Ertl et al., 2017; Good et al., 2008; Cundiff et al., 2013; Spencer et al., 1999)

A stereotype is defined as a fixed, often simplistic generalization about a particular group or class of people (Cardwell, 2014, p. 227). Of particular relevance to this research is the stereotype that men are better at mathematics and science than women (Good et.al, 2008; Spencer et al. 1999). Physics and physical science which are the focus of this research requires science and mathematics competence. These fields are still overly male-dominated and masculine where "women are under-represented compared to life science subjects" (Turnbull et al., 2017). In a study that investigated gender ideologies in male-dominated academic fields, it has been found that the negative ideologies position the dominant subgroups—White men—as superior and normative, further marginalizing women and racial minorities (Banchefsky et al., 2018).

There are successful stories of women and other minority groups in science. However, 'men do science' is still a widespread stereotype. Lederman and Bartsch (2001) have claimed that the normal image of scientists has been and continues to be, "white, middle/upper class, solitary, laboratory-oriented man, and it is necessary to modify 'scientist' when we try to include other types of people" (p. 9).

A research analysis of 350.000 participant samples in 66 nations has revealed that (Miller, Eagly & Linn 2015, p. 640) "gender-science stereotypes are still strong even in nations with small gender differences in overall science participation". So, even the number of women pursuing a science degree and career is increasing, the stereotypes are slow to change.

In another study (Ertl et al., 2017), it was revealed that stereotypes about females' abilities, interests, and need for conformance contributed negatively to women's academic self-concept. They stated that even if women get good grades at a high level of STEM subjects, stereotypes still corrupted their self-concept. Their findings have important implications for showing that the achievements of girls are (stereotypically) attributed to hard work instead of talent. (Ertl et al., 2017). In this situation, under the effect of stereotype and bias, women are more likely to develop negative emotions such as anxiety or self-doubt in STEM context (Freedman et al., 2018). Research has demonstrated that (LaCosse et al., 2016), in samples of undergraduate STEM students, men's STEM setback has been attributed to external factors (e.g. bad luck), whereas women's STEM setback has been attributed to internal reasons (e.g. low ability). It has been argued that negative competence related stereotypes can reduce the motivation to a particular domain and lead to its abandonment (Schuster et al., 2017). They have concluded that creating less stereotypical STEM contexts can foster a positive effect on women's motivation and self-efficacy in STEM.

Lane, Goh, and Linn (2012) have reported that "people with strong ties to their gender seemed to be most affected by gender stereotypes" (p. 223). Butler (2014) argues that there are ways to downplay the relevance of gender in everyday life or to distort gender categories to the point where they lose their descriptive influence over us. Gender identity, on the other hand, is particularly significant for certain individuals as a way of opposing hegemonic influence within a particular gender category.I agree with Butler in her assessment that strongly defining ourselves in a specific way can confer a descriptive power on us, reinforcing the stereotypes associated with that identification.

Gender/sex stereotypes can be eliminated by removing gender labels in our minds, and by seeing a gender identity not as destiny, or maybe, as Fryer (2012) puts, "by thinking queerly about our sex, our gender, our race, our ethnicity, and our very selves" (pp. 11-12). It is not only to transcend our normative thinking but also to challenge the very terrain upon which thinking occurs. As suggested by Fryer (2012) normative thinking is a kind of thinking “whereby we accept the world as given to us- whereby we do not question the assumptions that underlie our everyday goings-on, nor do we see our role in the world as critical thinkers” (p. 5). For Fryer (2012), this way (thinking queerly) we can break the assumptions that “all professionals are white, that all presidents will be men, or that all people are straight” (p. 5).

As argued by Nosek and Banaji (2002) the strength of female gender identity was associated with increased negativity and weaker identification with math. This study revealed that women and men held equally strong implicit stereotypes linking math to males. Steele (1997) has argued that “for members of a negatively stereotyped group who are identified with domains in which these stereotypes apply, the threat of these stereotypes can be sharply felt and, in several ways, hampers their achievement” (p. 614). Steele (1997) defines this feeling of failure as a stereotype threat which is a situational a “threat in the air” - that, in general form, can affect the members of any group about whom a negative stereotype exists (p. 614). So, in a certain group dominated working environments, this group might justify their dominance by adopting certain stereotypes that treat this group as a normative and superior and denigrate other groups. Thus, increasing the number of underrepresented groups in science is important in terms of eliminating negative ideologies and stereotypes towards minority groups. Negative racial and gender stereotypes are likely consistently harmful to racial minorities and women alike.

Racial and gender ideologies might interact, and impact people with overlapping identities, such as women of colour, queer people of colour, etc. Also, a person’s gender, racial, and ethnic identities may have an impact on his/her science identity. Carlone and Johnson (2007) demonstrated a connection between the experiences and making meanings of science, gender, and race identities of women. They (2007) have found out that women of colour can persist in science without either gaining or being denied recognition from meaningful scientific others, but still redefining their understanding of what it means to be in science and whose recognition is important to them. I understand from this finding that one's perception, understanding, and performance of his/her identity is flexible and can be redefined. Individuals, especially underrepresented groups can reinterpret their identities in science, and create new and a wide range of 'scientist subjectivities' (science identities) for themselves and for those who are often excluded from doing science.

"An identity is a set of meanings that defines individuals in terms of the roles they occupy, the social categories or groups they belong to, and the individual characteristics that define them as unique persons" (Stets and Burke, 2014, p. 412). Carlone and Johnson (2007) have considered a prototype of being a scientist under three aspects: competence, performance, and recognition. For instance, especially for minority groups, a person can go into the science field, but s/he may still feel that s/he is not competent. Or s/he feels competent, but rarely recognized as a legitimate scientist by the scientific community or significant others. Stets and Burke (2014) claim that identity verification, which means having to do with social belongingness and integration, including being accepted and valued, is central in the identity process. So, for a scientist, being valued, accepted, and known by significant others are important in terms of increasing the sense of belonging and identifying themselves with the science identity.

It is not an easy road to take if you are different from the rest and if you do not adhere to certain social norms. In terms of science, for example, during an interview with Evelyn Fox Keller in 1990, Moyers (1990) claimed that when Keller set out in the 1950s to be a scientist, she discovered that it is a man's world, not only because most scientists were men, but because the language of science itself reflected masculine values.

For a broader understanding of science and gender relations and their effect on science identity development, what makes a 'woman' and a 'scientist' must be better discussed. According to the social construction of gender, 'woman' as a gender category is made and practiced by individuals in everyday lives through interaction, speech acts, bodily acting out, activities. Similarly, individuals learn how to be a scientist, how to attach to its norms and culture. The performative conceptualization of 'gender' and 'science' identity allows for a more fluid understanding of them, and for a transformation of the prescriptive stereotypes that come with these identities.

## 2.5 Masculine culture of physics & physical sciences and women's challenges within these fields.

Gender differences across science fields suggested that existing gender inequality in science is somewhat field-specific (Francis et al., 2017; Kalender et al., 2019; Cheryan et al., 2016; Gisler et al., 2018). For example, heavily male-dominated fields such as physics and certain subfields of physical sciences are viewed as more strongly associated with masculine stereotypes compared to relatively more gender-balanced fields such as life sciences and chemistry (Smyth & Nosek, 2015; Turnbull et al., 2017). In line with these studies, in this research, the focus was given to the physics and physical sciences as they show the largest gender imbalanced of all science disciplines in Ireland (HEA, 2017/2018).

Smyth and Nosek (2015) reported that the weakest explicit stereotypes towards both men and women in science were found in domains where women are more heavily represented, such as health and biological sciences, and the strongest were found in domains where women are least represented, such as physical sciences.. Similarly, in a recent study by Turnbull et al. (2017), the results showed gender differences in subject enrolment consistent with gender stereotypes. Their analysis found that after taking a first-year physics course, female students were around 2.5 times more likely to study life science subjects (medicine and biology) in later years compared to male counterparts. Turnbull et al. stated that (2017) gender differences in science subjects may not be present in early childhood but emerge by the end of high school, and at the university level, the disparity may even widen further. This argument is supported by influencing factors contributing to the gender gap at a more advanced level of science.

In study focused on young people to examine the discursive assumptions made in relation to gender and physics, it was identified three key factors: equality of opportunities, continuing gender inequality in and around physics, and construction of physics as hard and masculine subject (Francis et al., 2017). In another study (Gisler et al., 2018), it was found that perceived lack of fit, schooling differences, lower self-efficacy, and lack of female role models may represent some of the biggest impediments for attracting women into highly male-dominated STEM fields. It was further stated that (Gisler et al., 2018) the wider gender disparity at higher level scientific occupations may stem from unfair workplace practices, a lack of family-friendly policies, and/or workplace environments and institution-level factors.

An individual's disposition towards certain subfields of science may also be influenced by environmental context. Murphy et al (2007) found that women were affected by the numerical representation of women in conferences. They tended to have a higher level of belonging after they witnessed a gender-balanced conference setting. Murphy et al (2007) concluded that women felt more identity-safe among other women.

The lack of female role models in physics and certain subfields of physical sciences may also be a factor affecting the number of women getting into and progressing in these fields. In physics context, Kalender et al. (2019) claimed that the lack of female role models (e.g., famous female physicists or female physics instructors) and being one of the few female students in a physics classroom can communicate to women that their gender is not appropriate for the field. In another study, it was suggested that the lack of relatable role models cause women to believe that they will not be successful

(Cheryan et al., 2016). Apart from the factor of role models, Cheryan et al. raised (2016) other contributing factors influencing women's participation in certain science fields: stereotypes and perceived bias, insufficient early experience, self-efficacy, formal discrimination, math ability and performance, labour market, institutional forces, peer support, and attitudes.

Francis et al. (2017) draw attention to the importance of representation of women in physical science claiming that the symbolic hegemony that physical sciences are hard and masculine domain should be disrupted in order to increase the representation of women in the sector. Their findings (2017) suggested that the lack of women in physics, both in reality and as presented in popular media, perpetuate the construction of physics as an inhospitable domain for women. In another research (Gonsalves et al., 2016) which focused on masculinities produced related to physics, it was claimed that masculinities are not only relevant to men, but also in relation to women's experiences in physics. In this study, masculinity was viewed as performative rather than something inherent to men. What I have understood from Gonsalves et al. research is that women also perform masculinity rather than passively perceive the culture of physics as masculine. The construction of masculinity, in Gonsalves' et al. analysis, involves performing, practicing and expressing different masculinities through the practice of physics in a different context (e.g., physics classrooms, lab) and taking up physical skills (e.g., technical competence, analytical skills, hands-on skills, strength, and physical efforts).

From the studies above, it can be concluded that the difference of women representation across science disciplines can be associated with the strength of gender stereotypes and/or the heavily male-dominated and masculine nature of certain scientific fields. My argument here is that in order to gain a deep understanding of the science identity development of women participated in this study who majored in physics and physical sciences, the analytical outcomes of various related studies explained above will provide me a theoretical foundation which I develop in the next chapters. (See Chapters 5 and 6).

## 2.6 Developing a science identity

### 2.6.1 Defining identity

Identity formation is a complex process. Thus, studying identity is a challenging and daunting task for researchers. As Carlone suggested (2012) part of the problem lies in the difficulty of "theorizing the concept in rigorous, cohesive, and empirically accessible ways" (p. 9).

Identity can be defined in terms of being recognized as a "kind of person in a given context" (Gee, 2000, p.99). Further Stets and Burke (2000) have argued that one's identity is composed of self-views that emerge from participation in certain activities and identification in terms of membership in particular communities and roles. In other words, identities are both internalized from our experiences which reflect personal thoughts and emotions, and also constructed through relations with others. In framing my approach to identity, it is important to understand what a person does, how s/he acts, and how s/he feels. For analysing science identity development of women, I got inspired by Gee (2000) and Butler (1988) to conceptualise an identity.

Gee's identity theory depicts identities as socially constructed with a particular reference to the negotiating process of recognizing and being recognized within particular discourses. From his perspective identity is being continuously negotiated through one's interpretation of themselves and his/her membership with relevant communities. This practice involves countless possibilities. In the case of women's science identity development, constituting science identity involves doing science, making meaning out of it, and viewing themselves as a part of the scientific community. Gee describes this as an activity-based identity. In Gee's argument (2017, p. 86), "activity-based identities are named by both a noun (for BEING) and a verb (for

DOING)". For example, a scientist does science which leads them to show persistence in science activities, thus, be labelled as a scientist. 'Scientist' is a general label. However, below the general label, true diversity exists (Gee, 2017). In my view, there are various ways of performing science identity.

Gee argues (2000) that at one period of history certain combinations of identities result in recognition of a certain sort, while at a different period of history the same combination would be unrecognizable or recognized differently. In my case, as I previously discussed, women's accomplishments in science have historically been under-recognized, and credit is disproportionally given to male scientists. I argue that when women constitute their science identity today, they also transform the values, norms, and activities of science as well as the particular characteristic of the group 'scientist'. Gee suggests (2000, p. 86) stated that "there is a reciprocal relationship between a person and a social group and its core defining activity". So, the dynamic of these interactions makes 'identity' active, fluid, constantly changing, and transformative, not stable, and pre-determined.

My identity framework also drew from Butler's performativity theory. In this study, identity is not considered as an ontological quality which corresponds to the essence of the individual. Rather, it depends on performative acts and speech acts. Repeated performances of a range of behaviours and activity along with linguistic action are called performativity. From this perspective, 'being' is integrated into both the linguistic patterns and repeated behaviours (acts). Butler used her theory of performativity to examine the way gender is constructed through. According to Butler (1988), the various acts of gender creates a gender. In order to examine the gender and science identity of my participants, I used the theory of performativity on gender and science identity construction. My focus was on the power of language that the participants used to describe 'what woman means', and 'what scientist means to them' as well as 'how they do science' and 'how they do gender'. Being a scientist is based on repetitive performances that require socialization of individuals into the norms and discourse practices of science (Brown, 2004), much as gender is an act that is rehearsed, actualized, and replicated (Butler, 1988).

### 2.6.2 Science identity construction

Researchers have presented three major conceptualizations for what forms science identity:

1. competence, performance, and recognition (Carlone & Johnson, 2007)
2. match between popular representations of science, the manner in which it is taught, and the aspirations, ideals, and developing identities of young adolescents (Archer et al., 2010)
3. self-efficacy, intention, science behaviour, attitude and involvement (Stets et al., 2016).

These are important studies dealing with the primary driver of science identity which leads to participation in the science pathway. There has already been a rich literature which directly investigates science identity development of women, especially case studies through interviews. Most of these studies have adopted Carlone and Johnson’s identity analysis model and further developed it (Herrera et al. 2012; Hazari & Potwin, 2013, Espinoza, 2011). Recently, another framework proposed by Kim et al. (2018) examined the science identity development of women from a social identity perspective. They paid particular attention to the role of the scientific environment. They argued that despite young women’s high achievement and interest in science, the outside environment such as classes, peers, parents, teachers may make them feel unwelcome. They suggested (2018) that who is part of the in-group or outgroup of STEM fields can be changed through intervention and educational programs.

I acknowledge that identity development is a complex process. The conceptual frameworks of the science scholars have highlighted many important variables and constructs related to science identity. In science identity development along with an individual's interest and competence in science, peers, teachers, classroom activities, materials, environment play key roles in support of science identity. As stated by Potvin et al. (2013, p. 282), "the development of interest is central to the development of identity". In their work, they built up their framework to include interest factors along with recognition and competence/performance.

In another study, Robinson et al. (2018) concluded that one's perception of competency in science was a significant predictor of developing a strong science identity. Carlone et al. also (2007) illustrate that a science identity is accessible as a result of an individual's competence and performance as a science person.

There are already some studies which evaluate the sense of belonging on science identity development in specific STEM disciplines (Espinosa, 2011; Smith et al., 2013; Stout et al., 2013; Good et al., 2012; Trujillo, 2014). The researchers have found that women's sense of belonging impact their achievement in STEM and their subsequent intent to pursue in STEM domains. Results also have shown that community involvement and mentoring positively affect science identity (Good et al, 2012; Trujilo et al., 2014) while negative cultural stereotypes about one's group ability-are associated with a lower sense of belonging (Stout et al., 2013). These findings have highlighted the importance of developing a sense of belonging for a strong science identity. Besides, engaging a science activity also strengthens the science identity (Stets et al., 2017).

### 2.6.3 Physics identity construction

Carlone and Johnson (2007) established a framework for science identity in which performance, competence and recognition are three interrelated factors that constitute the characteristics of a person's science identity. By including interest as a fourth constructing factor, this framework was extended for students' physics identities (Hazari, 2010). Hazari et al (2010) identified four influencing components of a student’s physicist identity: 1) interest which refers to the personal desire to understand physics, 2) competence which is a belief to understand a physics content, 3) performance which is the ability to perform physics task and 4) recognition which means being recognised by others as a physics person. In a later study (Hazari et al., 2017) in which they examined female undergraduate students’ physicist identity, recognition was extended to include a self-recognition, a perceived recognition from others and a perceived recognition for other students around them. In this study, they found out that high school physics teachers play an important role in helping students develop positive physicist identity.

In Ireland where my research was conducted, most Irish students are introduced to lower secondary physics by a non-specialist physics teacher (O’Neill and McLoughlin, 2020). They emphasized the low level of students, particularly girls, choosing to study higher-level physics through the 2018 State Examinations Commission statistics, which showed that only 27 per cent (2075) of the 7535 students who chose upper level physics were girls in Ireland. This study is consistent with the findings of Hazari et al, research (2017) that second-level physics classes and physics teachers are significant in shaping students' career choices in physics and establishing their physicist identity. This finding of the study by O'Neill and McLoughlin underpins the statistic of HEA (2017/2018) that physics and physical science are the most gender-unbalanced fields of all science disciplines in Ireland.

From a gender perspective, interestingly Hazari et. al (2010, p. 997) revealed that “examples of female scientists and female scientist guest speakers, had no significant influence on females’ physics identity indicator”. This finding contradicts previous research (Kalendar et al., 2919; Cheryan et al., 2016; Francis et al., 2017), which indicate that lack of female role models (e.g. famous female physicist, physics teacher, media representation of a physicist) negatively affect women’s/girls’ physicist identity development.

Recent research on physicist identity has stressed the importance of a sense of belonging (Hazari et al., 2020; Stout et al., 2013). Hazari et al. (2020) stated that sense of belonging had a direct effect on physics identity especially for senior female physics undergraduates, which suggest that developing a sense of belonging to a community becomes more important as the students become more involved in physics community. This finding is important for understanding how women construct physics identity in the context of a physics community and a sense of belonging. For young women physics identity means being different from the other girls (Archer et al., 2017). The majority of the girls interviewed in Archer et al.'s study (2017), who aspired to pursue physics tended to perform non-girly gender performances that coincided with cultural arbitrary which considers femininity incompatible with physics identity.

Recent physics identity research has also focused on how multiple identities intersect and influence the development of physics identities and participation in physics (Avraamidou, 2019; Hyater-Adams et al. 2018; Hyater-Adams et. al., 2019). From an intersectional perspective, Avraamidou (2019) used Carlone &Johnson's science identity framework to analyse how science identity intersect with other identities and influence young Muslim woman's participation in physics. Her findings (2019) revealed that becoming a physicist is a profoundly personal, emotional, and intimate process in which multiple identities overlap and sometimes clash. Especially in physics as a predominantly male-dominated and White field, when a women's religious identity becomes visible through gender identity performance (i.e. wearing hijab), she feels like a "constant outsider" (Avraamodou, 2019, p. 4) which influence her recognition as a physicist by others and consequently hinders her sense of belonging. In another study (Hyater-Adams et al., 2019) which they used a critical physics identity framework to analyse how institutional and systemic factors impact the development of physics identity. Their findings revealed that similar to Avraamodou's study (2019) recognition impact the ways that Black women position themselves as physicts. The results also revealed that being in the field means enduring more negative recognition from others.

The studies discussed above provided me with a valuable perspective as the majority of the participants in my study were students and researchers in different subfields of physics.

### 2.6.4 The model of 'science identity' used in this study

-In this study, science identities of women were explored in two dimensions: a sense of belonging and performance. Physics and physical sciences are still considered to be "hard and masculine domains" (Francis et al., 2016, p. 172). In this study, a sense of belonging is one way to examine the extent to which participants feel like they fit in physics and physical sciences; performance is another way to examine how they constitute their identities "along and against the gendered norms of physics" (Danielsson, 2009, p. 36) and physical sciences.

Within the research literature on sense of belonging, the focus is on a feeling of a belonging to a particular group, people and activities (Mooney et al., 2018; Good et al., 2012; Stout et al., 2013; Freeman et al., 2007; Trujillo et al., 2014; Haxa). Unlike the previous studies, in my study there are two facets of the sense of belonging, one of which is related to the development of attachment to the scientific community (community attachment) and the other to the development of an interest in science (emotional attachment). The factor of interest was previously used in Hazari et al's (2010) study in which they have developed a framework for physics identity in high school. Hazari et al.'s (2010) interest dimension is treated as a separate variable. In this study, it is framed within the concept of sense of belonging as it refers to emotional attachment to science as individual level.

Performance, which is another aspect of science identity construction, refers to the acts and discourses, in other words, *doing science.* In the case of science identity, performance refers to the presentation of the self as a scientist, in other words, women's practices of doing science and making meaning out of it. It also refers to participation in science, both individually, collectively, through acts or languages (speech). It is influenced by Gee's activity-based identity and Butler's theory of performativity.

I acknowledge that individuals have multiple identities that interact and intersect which is largely determined by society, history, culture, environment as well as individual and communal practices. Identities are performative and discursive. They are also vulnerable and transformative. In the case of science identity, I believe that there is so much work to be done from a variety of different theoretical and conceptual perspectives in order to understand an individual's science identity development. In this study, I conceptualize science identity under the framework of a sense of belonging and performance. In doing so, I looked at the lived experiences of women, their self-evaluation, their struggles, and thoughts as women in science.

In this study, science identity is also based on an assumption that one's gender and overlapping identities may influence her science identity. For this reason, the intersectional feminist perspective is also integrated into my science identity analysis. As 'women' is the agent of this research I looked at the role of their gender identities in their science identity development. However, gender identity is not my main focus, and it is only based on women's self-expression and self-identification.

## 2.7 Conclusion

This chapter gave a general summary of the historical background to the women's relationship with science from the emergence of modern science until the contemporary period and present time. Then, it explained gender stereotypes and bias in science which may influence science identity development. Particular attention was paid to the masculine culture of physics and physical sciences and women's challenges in these fields. This chapter concludes by discussing identity construction with particular emphasis on science identity, physicist identity and science identity framework that guided my analysis.

# Chapter3 : LITERATURE REVIEW -DOING GENDER-

## 3.1 Overview

This chapter provides a summary of how gender has been conceptualised in this study, briefly introducing feminism, intersectionality, and queer theory which has been useful with this research.

The first part of this chapter briefly introduces feminism, then the term gender and sex are explained. Next, the notion of 'woman,' as well as organizing around the category of 'woman,' is then debated in feminist politics. Following that, there is a discussion of women's individual and collective identities, feminist self-labeling, and the dilemmas of women's identification with feminism.

The second part of this chapter defines intersectionality and its usefulness for feminist studies, particularly for this study. It specifically focuses on increased importance given to issues of difference and recognition of women’s multiple experiences.

The final section delves into queer theory. I address how gender performativity has affected how I conceptualise gender and how I approach the gender identities of the women who took part in this research.

## 3.2 Feminism, gender, and identity

*“Ain’t I a Woman?”*
*Sojourner Truth, 1851*

Feminism is one of the most influential social movements and ideologies since the mid-twentieth century. It includes a number of egalitarian social, political, and cultural movements, sets of ideas and philosophies concerned with gender equality and equal rights.

Narrowly defined, “it refers to attempts to attain equal legal and political rights for women, while in its broadest sense it refers to any theory which sees the relationship between the sexes as one of inequality, subordination, or oppression, and which aims to identify and remedy the sources of that oppression” (Mendus, 2005, p. 291-292).

Butler disagrees with the fixed definition of feminism as she said she wants to see it “alive, becoming more expansive and powerful” (Butler, 2017, p. 462). There is no doubt that feminism has been evolving and expanding since the first wave in the late nineteenth century which mainly centres on gaining the right to vote and opening up opportunities for women in the public sphere. Feminism's origins can be traced hundreds of years before the first wave, even also back to ancient times. To me, it is difficult to pinpoint exactly when it began in people's minds because it's also about individual fighting, speaking out, and resistance against patriarchy and injustice, which can be found in women's literature and oral histories throughout history. Since beginning as a collective movement in the late 1800s, it has progressed over time to become more than just having equal legal rights. From the idea of sisterhood to the differences across women, from the reproductive rights to recognizing sexualities, it is now revolving around the idea of ‘feminism for everyone’, which deals with more diverse and complex issues. It is all about creating equity and justice for all races, genders, and sexualities at its heart, both as an individual and as a collective movement. As Ahmad argued (2017, p. 1), “it brings to mind women who have stood up, spoken back, risked lives, homes, relationships in the struggle for more bearable worlds”.

The questions of gender and sex are probably one of the most debated topics of feminist theory. Aside from long-standing debates of gender and sex, gender is widely considered more like a social construction that relates to gender roles and individual’s concept of themselves (Connell, 1987) while sex refers to biological characteristics based on genetics and genitals. In line with this statement, Connell argues that gender is a process rather than a thing (Connell, 1987). I agree with Connell when it comes to my understanding of gender. Otherwise, it would rely on biological determinism which restricts the possibilities of social change.

Even if sex is considered as a label assigned at birth based on reproductive organs it is still a "social marking of natural difference" (Connell, 1987, p. 79). Sex is always considered to fall into binary categories of female and male except for intersex. Connell further explains (1987) that sense of maleness and females involves "size and shape, particular physical skills, habits of posture and movements, the image of one's own body, and the way it is presented to other people" (p. 84). Thus, to her, maleness or femaleness is not a consequence of chromosomes or genitals, on the contrary, "it grows through a personal history of social practice and a life-history of society" (1987, p. 84).

Connell's interpretation of sex challenges the view of sex is what individuals are said to have, while gender is what individuals are said to be. Butler makes similar points in the case of the nature of sex. According to Butler, it is not possible to know sex as distinct from gender (1988), as "the natural facts of sex itself are discursively produced by various scientific discourses in the service of social and political interest" (1999, p.10). In other words, for Butler sex was maybe always a gender.

What does gender identity mean in the sense of this thesis, after all of these discussions of gender and sex? The view of the social construction of gender (Connell, 1987) and the performative aspect of gender (Butler, 1999) which is explained in the following discussions give me a lens into my conceptualisation and understanding of 'gender' in this thesis.

Gender identity, like most of the other social identities, might be relational and contextually variable, but they remain fundamental to one's experience of the world (Alcoff, 2005). From this view, one's gendered experience involves direct agency. Similarly, but in different words, Butler (1999) mentions the power of language operating behind gender identity construction:

> *There is no gender identity behind the expressions of gender; that identity is performatively constituted by the very "expressions" that are said to be its results (p. 33).*

Butler, in my view, does not deny agency or the subject, but rather stresses the importance of language and expressions in the constitution of identity. For Butler (1993), the agency does not have pre-social status. What one might call "agency" or "subject" is the effect (result) of self-repetitions and "discourses that has the capacity to produce what it names" (Butler, 1994, p.33). From this perspective, the notion of female essence or agency which is linked to biological traits is contested. This view of the construction of gender identity opens the possibility of deconstruction of the gendered subject. Thus, what has been represented as natural can be revealed by discursive powers.

This view has been highly criticized by some feminist theorists for its lack of essentialism which differentiates sexes, and consequently for denying women's shared identity and characteristic which motivates them to engage in collective movement. Most of them locate women's essence in biology, reproductive roles, and cultural behaviours. For example, for McKinnon (1983) all women are harmed by a system of male dominance.

I agree that there are certain experiences, histories, economic, social, and biological structures shared by most women, but this does not mean that becoming a woman is predetermined and unquestionable identity. Moreover, I argue that women's experiences are very much influenced by sexual orientation, religion, class, race, ethnicity, ability, and colonization which is discussed in the following sections.

### 3.2.1 'Woman' as a gender category

The definition of a woman is fluid and difficult to pin down. It applies to a female human being in general, but how do we know who is female and who isn't? Many women (maybe) do not wish to associate themselves with femininity. Being a woman is not about how you look on the outside. It also has nothing to do with being physically capable of growing eggs. In my opinion, it is based on people's self-expression of their own gender identity. It is free-floating and unifying at the same time.

If this category is socially constructed and based on expressions and performances, how are the real-life problems of women such as reproductive rights, maternity, pregnancy, childbirth, and abortion which are related to the female body and women's biology be solved without the universal category of woman and collective women's movement? If this category is determined only by biological determinist conception, then how can 'woman' include trans women or drag queens? According to Butler, the feminist movement needs alliances. She (2017) says that a practice or a movement does not require an identity. She adds that sometimes we have to let the identities go, or at least "not let them serve as organizing principles of movement" (2017, p. 463) In my opinion, she believes that each person is made up of others, implying that there is an I in You. So, even though our histories and stories are distinct, there must be a connection that ties us together in the face of a collective struggle. My interpretation of Butler is that feminism does not need a 'woman' category or a woman's essence shared in common by all women in order to deal with women's related issues.

The very existence of a category called woman creates a philosophical problem in feminism. On one hand, 'woman' is considered to be discursively constructed and there is no true essence of womanhood, in another hand, as Grosz (1989, p. 55) has asked, "if we are not justified in taken women as a category, what political ground does feminism have?" In this line of thought, the political action on behalf of the woman requires some understanding of what *is* a woman (Goldenberg, 2007).

In my opinion, categorizing is inevitable, and feminism needs a degree of similarity or generality, as well as common life experiences, in order to organize and act politically. It is understandable for people who have a shared identity to speak out louder, but that does not mean this identity group has thick, impenetrable walls. ‘Woman’ as a gender category can be inclusive and can ally with other genders. As Goldenberg has claimed, “the inclusion should not be founded on sameness, but rather on differences” (2007, p. 144). In today’s feminist political arena, differences embrace women’s sexualities, bodies, other social identities, and different cultural and historical backgrounds. So, ‘woman’ as an identity category has many variables. However, the status of women as members of the not-men (Goldenberg, 2007) still constitutes the core of this identity. This, however, leads to an essentialist view of gender and sex.

People inevitably categorize things, nouns, acts and concepts, and each category has its own set of exclusion. As a result, feminism cannot avoid exclusion as long as woman is used as a core group in its struggle. For Butler, people name the categories and invest meaning in it. Within her vision, this meaning is never fixed, and it may have a different meaning at different times. Donna Haraway (1989) also argues that there is no ontology of female identity:

> *There is nothing about being “female” that naturally binds women. There is not even such a state as “being” female, itself a highly complex category constructed in contested sexual scientific discourses and other social practices (p. 174).*

According to her argument above the category of woman is discursively and performatively constructed. This view of Haraway and Butler’s contributes to the social process of gendering and fluidity of gender categories. Another view highlights the role of history and cultural interpretation of the construction of ‘woman’ as a gender category. According to Fraser (2013), gender identities are discursively constructed in historically specific social contexts:

> *In order to understand the gender dimension of social identity, it does not suffice to study biology or psychology. Instead, one must study the historically specific social practices through which cultural descriptions of gender are produced and circulated (p. 140).*

This view of Fraser rejects the gender essentialism but accepts the category of woman. She considers the social identities including gender as complex, plural in historical context, and shifting over time. For some feminist theorists (Alcoff, 2006) "gender is both positional and material which provides a necessary knowledge base from which to engage in feminist political debate" (p. 289). Being a woman, in this view, is influenced by biological anatomy, historical experiences, social structures, and relationships.

To put it more simply, the debates over the concept of woman in feminist philosophy never end. I accept that in feminism, there is no need for an essentialist conception of what or who a 'woman' is, but it is also clear that, despite their differences, women across the world face many of the same issues. Being a woman, in my opinion, is an open-ended phenomenon that is affected by gender roles and norms but often transcends them, i.e., being a woman is based on self-expression, sense of belonging, and performative acts. It also varies according to location, time, and culture. However, becoming a woman is not purely and fully expressive. It is also performative which in other words, it relies on certain kinds of repetitive acts which are both "socially shared and historically constituted" (Butler, 1988, p. 533).

The presence of a 'subject' in feminism is important for feminist politics, but the ontological construction of the concept of woman and female subjectivity must be reconsidered. This is necessary for inclusive feminism to "extend representation to subjects who are constructed through the exclusion of those who fail to conform to unspoken normative requirements of the subject" (Butler, 1999, p. 9).

### 3.2.2 Women's individual and collective identities

Feminist theory today is having a profound identity crisis. From a feminist perspective, not only the category of 'woman' but also the identity itself has been highly debated (Alcoff, 1988; Hekman, 2000; Butler, 1999). As discussed earlier one of the main critiques against identity comes from post-structuralist feminist theory on the account that identities are flexible, fluid, and shaped by discourses and are always open to transformation. On the other hand, from a cultural feminist perspective, women's identities are based on common experiences, demands, and goals which are accepted as a unifying basis of feminist politics. From an intersectional perspective, however, this unified category of women is illusory. It undermines women's different positions in terms of race, ethnicity, class, sexuality, religion, ability, and other social divisions.

Women's movement has often organized around an identity no matter what, and women's experiences, private or public, individual or collective, are always in the centre of the movement. The basic idea of identity, as explained by Yuval-Davis (2010), is the narratives, stories that people tell themselves and others about who they are, and who they are not, as well as who and how they would like to/should be. Both from an individual sense of self and a collective sense of belonging, the construction of identity is a perpetual state of becoming (Yuval, 2010).

Women's individual and collective identities include a sense of belonging (both individual and/or collective sense), self-expression, and performative acts. Individuals can belong in very different ways to their gender or other social identities. Sense of belonging is defined by Yuval- Davis (2006, p. 197) as "emotional attachment" and as "a feeling at home" In line with her definition, from an identity perspective which I will often refer to throughout my thesis, I define 'belonging' as an identification and emotional attachment to a particular place, concept, identity, or object. As Yuval- Davis (2011) points out not every belonging is important to people in the same way and the same extent, and emotions, as perceptions shift in different times and situations. From this perspective, expressing one's gender identity and developing a sense of belonging to it, in general terms, is situated in a fragile ground. To put it another way, being a woman can mean different things at different times and in different contexts, as well as in different circumstances. In other words, its meaning can change from one individual to another. As Yuval- Davis argues, following Butler, "the constructions of belonging have a performative dimension" (2011, p. 15). This view emphasizes the constitutive element of emotions over identity construction.

Unlike individual identity, collective identity entails a sense of connection with others. People who share a sense of togetherness identify themselves with a group and build the boundaries of the group. When it comes to women's movement and feminism it needs a sense of togetherness, a common conscience, and shared experiences. From this perspective, it is unavoidable for women's movement to be exclusionary, as "there is always something left outside once the boundaries of specific identities have been constructed" (Yuval-Davis, 2011, p.17). However, individuals within the groups can alter the definition of the group identity and make it more flexible and dynamic, but they still share some commonalities because their common experiences and histories, self, or bodily experiences put them in contact with the same things.

As stated by Taylor & Rupp (1999), feminism is more than a gender ideology, it is a collective identity. As well as I agree with this, I believe, feminism needs both collective and individual identity, conscience, and intervention. Not all feminist movement is easily detected (Ahmed, 2017) and it is not always collective. A feminist movement can also depend on an individual's struggles. However, a collective movement is much stronger, and it has more power to change the unequal structures in society and to make public claims on behalf of a group. Thus, the unitary aspects of identity are necessary for women's feminist movement. 'Women' has generally been the name of these collective feminist movements. Even if today's feminism is too much occupied with the question of identity, the category of women both individual and collective sense remains a vital part of feminist theory, politics, and activism.

In my opinion, even if the identity is formed by discourses and power relations, and always in process, people can still talk about their shared experiences formed around such identities. The construction of I as a woman relies on self-expression and self-performance, as well as it is a part of the collective 'us' as women.

### 3.2.3 Attitudes towards the label 'feminist'

This section has been developed in line with my third research question which is about the influence of the feminist movement on women's science identity development. The 'feminist' naming and its possible connotations are explained in the following arguments of feminist scholars and researchers.

Much research has focused on factors related to women's commitment to feminist ideology (Williams & Wittig, 1997; Zucker, 2004; Yoder et al., 2010; Cowan et al., 1992; Buschman & Lenart, 1996). William and Witting claimed that major contributing factors for feminist self-labelling were positive evaluation of feminist and previous exposure to feminist thought.

Buschman's (et al., 1996) study suggested groups consciousness and negative experiences that predictors of support for feminism. Their analysis also showed that the label "feminism" evokes many more negative responses than does the term "women's movement" across all clusters. The reason behind the negative perception of feminist may stem from 'stereotyping of the movement in popular discourse' (Buschman et al., 1996).

A survey by Cowan et al. (1992) found that a person accepting the feminist label would not only take a pro-feminist position on women's roles but also think highly of the feminist movement. So according to their study, the content of the feminist movement (awareness of inequality and challenging the traditional women's role in its core) and the approval of the context (participating this movement individually or collectively) made a significant contribution to self-labelling as feminist.

Zucker (2004) made a distinction between feminist activism and feminist view saying that self-labelling as a feminist is related to activism, but not necessarily related to having feminist views. She stated that many women who even if embrace feminist principles are reluctant to be labelled feminists. For Zucker, one explanation of that, as Buschman (et al.) also stated above, was the negative portrayal of feminism and feminists by the popular media. Egalitarians can be categorized within the distinctive group of women who reject feminist labelling but on the other hand who engage in feminist behaviour. Zucker's study suggests that egalitarians have a high level of feminist consciousness, but they take less public actions than feminists. For Zucker (2004), exposure to feminism through education, personal relationships, or personal struggles are favourable conditions for feminist identity, however, exposure to mass media where feminist is depicted as "deviant, man-hating, unrepresentative radicals who threat the society" (p. 425) and association feminism with extremism are barriers to feminist identity.

The feminist paradox was explained by Yoder et al. (2010) by saying 'I am not a feminist, but…' position wherein women reject the label but approve the beliefs commonly associated with being feminist. Like Zucker, Yoder et al. (2010) also differentiated feminist self-labelling from feminist beliefs. They found out that self-labelling is associated with increased feminist activism, independent of feminist beliefs.

In sum, while women can be reluctant to identify as feminists or engage in feminist activism, they may still maintain feminist values and promote feminist goals. From the findings of the studies above, involvement of collective feminist movement, as well as positive exposure and evaluation of feminism contributes to developing a feminist identity. Feminist identification appears to be a complex process that includes both ideological and evaluative components (Liss et al., 2001).

## 3.3 Intersecting voices among women

*"When we define ourselves, when I define myself, the place in which I am like you and the place in which I am not like you, I am not excluding you from the joining – I am broadening the joining."*
*Audre Lorde, Sister Outsider, 2007*

The lens of intersectionality was applied in this study to demonstrate and negotiate different subject positions of women who participated in this study in terms of their intersecting identities. The issue of intersectionality will be broadly discussed in this chapter before it is further explained with a focus of its contribution to the theoretical framework in the following chapter (see Chapter 4).

The definition of intersectionality is not a simple task. The difficulty in providing a clear-cut definition of intersectionality arises from its traveling meaning over time and is conceptualized in different ways in academia, politics, and activism. Collins suggests that just as the knowledge, intersectionality itself is socially constructed, and transmitted, legitimated, and reproduced (Collins, 2015). Depending on the context, it is a field of study, a set of methodology, an analytical strategy, a theory, a critical praxis, and a political tool.

Rather than discussing what intersectionality is or should be /should not be, I like to think of it as a way of thought: intersectional thinking. Intersectional thinking requires understanding people's lives with complexity and to make visible the identities and experiences of people who have been silenced, subordinated, or erased. It also requires analysing the hierarchies and system of domination that permeate society as well as to remove the filters (stereotypes, misconceptions) and change the lens you look through (Collins & Andersen, 2007).

The concept of intersectionality has been rooted in black/women of colour movements. It was coined in 1989 by Kimberle Crenshaw to address the particular situation in which Black women are subordinated (Crenshaw, 1989). Over the last two decades, the term ‘intersectionality’ has been widely used in the interdisciplinary fields of women’s studies, critical, ethnic, and race studies. The meaning of intersectionality has also travelled and transformed. Not only gender and race but also other social divisions have been included. Collins (2015) explains the consensus about the framework of intersectionality as such:

> *The term intersectionality references the critical insight that race, class, gender, sexuality, ethnicity, nation, ability, and age operate not as unitary, mutually exclusive entities, but as reciprocally constructing phenomena that in turn shape complex social inequalities (p.2)*

These social divisions and differences as an additive and constitutive process vary in time depending on the culture and location as well as depending on the hegemonic discourses in a particular society.

Social divisions, stratification, and inequalities that shape individual and collective experiences of people may evolve in time and may vary across cultures and locations and are inextricably linked to issues of power. Thus, intersectionality requires analysis and criticism of the existing system of power and domination along with the system of privilege and inequality.

The concept of intersectionality has gained considerable visibility within feminist and women’s studies especially with the rise of third-wave feminism which centred on the issues of inclusiveness, diversity, politics, and representation of difference. After second-wave feminism which had universal goals for ‘all women’, it was first ‘class’ and ‘race’ that cracked second-wave feminist’s claims to universality. The second wave feminism focused more on women’s exclusion from the public sphere, women's participation in the labour force, gender roles, and patriarchy which oppress women. Second-wave feminism's responses to these issues were challenged by people of colour and lesbian feminists who criticized that feminism over-emphasized the experiences of upper-middle-class white women. They denied the universalist claim that women share a common set of experiences and a common gender identity.

The third wave sees women's lives as intersectional, indicating how class, race, ethnicity, nationality, religion, sexual orientation, ability, and gender are all important factors when discussing feminism. The advantage of highlighting women's differences avoids the problem of essentialism and accepts the multiple kinds of social constructions. Despite the differences across the women as social, political, and cultural subjects, women still have common practical real-life problems. "The study of an individual is a way of revealing the social structures shaping collective experiences" (Andersen & Collins, 2007, p.15). This way we, as women, can discover our common experiences and see the impact of our overlapping identities on our experiences. As Zack (2007) points out "there is a rich and troubled history that all women can, in fact, relate to, even after their differences have been emphasized" (p. 205). From a feminist perspective, such commonality is important if women want to change the world economically, politically, socially, and legally.

Intersectional feminism starts to become blurred when lists of differences seem endless and indefinite. There is ambiguity about the questions such as: who defines the differences, how the differences are defined, which one of these differences considered to be important, and why particular differences are given recognition while others not? Yuval-Davis (2011, p.9) explains this giving the rainbow example: "rainbows include the whole spectrum of different colours, but how many of these colours we distinguish depend on our specific social and linguistic milieu." She (2011, p. 9) further states that "the struggle of recognition includes an element of construction" along with identification and an emotional attachment (belonging) to particular social positionalities. In that case, it is crucial to examine how particular identities and positionings (both individually and socially) are built, as well as the norms on which they depend, within a given social, cultural, and historical context, and how these positionings interact in that context.

One set of critiques of intersectionality in feminist scholarship involves that it heavily centres the experiences of oppresses groups through personal identity narratives. Collins (2009) expresses that it certainly provides an important contribution to our understandings of how people experience and construct identities within intersecting systems of power. Yet, she further makes a compelling argument that it is shifting away from social structural analysis of inequality. I agree with Collins that intersectionality needs to be linked with deep analysis of system and structure which enables researchers to understand how unjust power relations are organized, operate, and sustained. This way, the intersectional analysis would not be reduced to the theories for the oppressed only. As Dill and Zambrana point out (2009) within intersectional analyses, unveiling the workings of power, which is understood as both pervasive and oppressive, is vitally important. Therefore, intersectionality can contribute to feminism by deeply analysing the unjust and arbitrary power hierarchies that intersect with patriarchal social order and their effects upon individuals and groups.

I suggest that intersectional feminism needs to focus on solidarity through coalition rather than separation. As Ahmed (2014) points out, solidarity requires both dedication and hard work, as well as recognition even though we do not have the same feelings, lives, or bodies, we do share common ground. Women can be united based on their mutual interests and goals, shared experiences, and shared history. Nonetheless, they are divided by class privilege, racism, sexual orientation, and so on.

If women's social individual identities, such as race and gender, are so important to their self, organising around them will only promote cooperation, mutuality, and awareness-raising. Some feminists argue that the despite the differences across women, organizing around the category of ‘woman’ reinforces the essentialist claim about gender, and when women as well as other marginalized groups name and repeat their “wounded attachment” to this particular identity, they participate in their own subjugation. Wendy Brown represents the most extreme example of this idea. She (1995) argues that identity-based political organizing reinforces oppression and creates social inequalities. Unlike Brown, I claim that organizing around an identity does not itself bring essentialism. It is like the movement of the will to become a Subject, and strive to survive (existing), or a movement of the will to live itself. However, breaking the essentialism requires questioning and transforming the social norms that exist around that identity in order to it dynamic, fluid, and inclusive.

Intersectionality was used in this research to understand how power works across women’s intersecting identities, paying particular attention to “the power relations that result in structural inequalities” (Bilge, 2013). That was examined indirectly by analysing the deeper meanings behind the participants’ words (See Chapters 5 and 6). Thus, attention was paid to the specific times, places, social structures, language both literally and symbolically as well as to silences, breaks, and emotions in narratives.

## 3.4 Crossing the boundaries- Queer

*“Identity is neither the reason for one’s being there nor the end-goal for politicization itself. It marks something about my position in my travels, but it is not my ground, my epistemology, or indeed my final stand.”*
*Judith Butler, “There is a person here”*

Queer theory, just like feminism and intersectionality, was used as a theoretical construct to conceptualize ‘gender' as well as an empirical lens to examine and view the women's narratives in this research. In this section, the general overview of queer as a way of thought and worldview, which has had a significant impact on me and my research, as well as Butler's theory of performativity, which has informed how I conceptualise gender and sex.

Queer is both a political and philosophical word that has been used in various situations by various people from identity politics to political activism, from a philosophical positioning to a mode of methodology in academia, from a political perspective to a form of self-identification. The word, queer, itself is as fluid as it is used.

Even if queer has arisen in sociology, politics, the streets, and even mainstream culture as a concept to describe many diverse identities that make up the LGBTIQ community, and is mostly used for the fight to recognize different identities and their rights, which I believe is understandable, queer is, in my opinion, more than any of these. It is a way of thinking and living. It is a perspective that actually questions and challenges all the labels, identities, and categories that are assumed to be valid and normal. As explained by Warner (1991) queer is also a rebellion:

> *Every person who comes to a queer self-understanding knows in one way or another that her stigmatization is connected with gender, the family, notions of individual freedom, the state, public speech, consumption and desire, nature and culture, maturation, reproductive politics, racial and national fantasy, class identity, truth and trust, censorship, intimate life and social display, terror and violence, health care, and deep cultural norms about the bearing of the body. Being queer means fighting about these issues all the time, locally and piecemeal but always with consequences (p. xiii).*

In view of such an argument, queer theory involves being able to challenge social institutions and accounts that places certain standards on people, as well as combatting bigotry, homophobia, hate in general and among minority communities. It is a form of local and global alliance-building that brings people from all walks of life together, regardless of their differences. As Butler said (2010), queer is a politics of alliance across difference.

Queer theory investigates sexuality and questions the fixed notion of identity by suggesting the deconstruction of sexual categories centred on heterosexuality. It stresses gender fluidity as a new way of thinking about gender identity. Queer argues that there are multiple subjectivities beyond the man-woman binary. Queer challenges and disturbs any stable categories including 'woman', as well as hegemonic structures and discourses that lead to the reproduction of gender, sex, and gender/sexual identities as fixed. However, feminism embraces 'woman' as a gender category. Feminism focuses on the theory of patriarchy and the analysis of gender in order to understand gender inequality. Despite Queer's focus on deconstruction and fluidity of identities and feminism's focus on the historical, cultural interpretation of identities of women, they have more in common to intersect than to separate.

The relationship between queer and feminism is a "complex dynamic of oppositions, contestations, and intersections" (Richardson, 2006, p.21). However, as Butler has pointed through an interview with Ahmed recently, (2016) we can think about bringing feminism into closer relation to queer theory. What she offers is an alliance instead of a set of unifying. In the context of gender identity development, being recognized and valued through one's gender/sex is important. Butler (2010) points out that to be a subject at all requires first complying with certain norms that govern recognition – that make a person recognizable. In order to be recognized as a certain gender identity in the law, in the public and private sphere I do believe that queer alliance with feminism is vital as it can provide a new understanding of gender/sex by examining how gender and sexuality are formed, reproduced and enforced. It is almost as critical for feminism to represent women politically as to question the essence of 'woman' in order to unchain it.

### 3.4.1 Gender performativity

The view that gender is performative has significantly shaped both individual and collective understanding of gender and gender identity. This view has raised controversial arguments in feminist theory and politics. According to the theory of performativity, as explained by Butler (2004, p. 218) “if gender is performative then the reality of gender itself, produced as an effect of the performance”. This means that there is no gender identity prior to the expression and act (doing) of gender because that identity is “performatively constituted by the very expressions that are said to be its results” (Butler, 1999, p. 33). Butler’s argument is based on the claim that performativity is not self-expression or self-presentation, it refers to the speech and bodily acts that create the thing they describe. It is neither a costume that people can wear this day and change another day or a role they do. It is both conscious and unconscious behaviours repeated and naturalized.

According to Butler, there are two dimensions of gender performativity: it is an unchosen situation of gender assignment, and the other one is performative action which is how are engaged in the practices and expectations of the assigned gender. In both cases, gender is not related to the essence of gender identity determined by biological, physical, cultural, or historical factors. In Butler’s own words (1988): “gender is not passively scripted on the body, and neither is it determined by nature, language, the symbolic or overwhelming history of patriarchy (p. 531).

From a feminist point of view, Butler’s criticism of gender and gender identity leads to the death of the subject, which suggests that there is nothing left outside the language, no real essence of womanhood. At this stage, the autonomous and self-determined subject of feminism has been replaced by fragile and deconstructive self. In this situation, feminist commitment to women’s agency and sense of selfhood is claimed to have been undermined by Butler’s theory of performativity. Benhabib (1999, p. 338) argues that “the overly constructivist view of selfhood and agency leaves little room for the possibilities of creativity and resistance".

Benhabib's criticism is right on the account that people need to exist and be represented in order to survive. However, Butler does not deny certain kinds of biological differences or a need/strive to be recognized. For Butler, the category of women is always open which means that it has the possibility of transformation. As Butler (2001) said through an interview with Breen, Brookey, and Blumenfeld, the performative construction of gender does not mean that identity categories are no longer available. One can still organize around specific gender identity, for example, namely 'women'. However, as mentioned by Butler (2001) "one has to be open to the notion that we do not know yet who else will ally with that sign or when that sign will have to be relinquished in order to promote another political goal" (p. 23).

In this study, heavily influenced by the theory of performativity, 'woman' as a gender category is viewed as something 'doing' instead of an inherent aspect of whom a person is (Butler, 1999). In the context of the analysis part of this research, 'doing gender' is crucial to my understanding of gender as a social construction. Giving a discursive account of gender, I examined how women create and negotiate their gender identity (See Chapters 5 and 6). To better understanding the performative and discursive aspect of 'gender identity' I included Butler's performativity theory in my literature review.

## 3.5 Conclusion

This chapter began with an overview of feminism and the feminist interpretation of sex and gender. It was followed by discussing 'woman' as a gender category, women's collective and individual identities, and general attitudes towards 'feminism'. Then it moved to a discussion of intersectionality and queer theory with a particular focus on different voices of women and gender performativity.

# Chapter4 : Methodology

*"Feminism is, in essence, -a method for understanding, from a marginal or boundary-dwelling perspective, one's own participation in socially constructed realities, both politically and personally, both socially and cognitively."*
*Susan Leigh Star, Strategic Heresy as Scientific Method: Feminism and Psychology of Consciousness*

## 4.1 Overview

This chapter provides a detailed description of the approach taken; the instruments used and developed to address the research questions in this thesis. I begin with a brief explanation of the overall research design of this study. Thereafter, I present the aim of the research and the research questions. After I explain why I have applied a critical constructivist research paradigm by describing why it was judged useful to employ it for this research, the contributions of Feminist, Intersectional, and Queer theory to this research from theoretical and analytical perspective is described.

After I provide information about my academic and professional background, I discuss my positionality as a researcher, and some of its influence on the data generation and analysis process. I specifically focus on how reflexivity is involved in the generation and the treatment of the data.

Then I present my arguments for adopting the research approach used, and data generation instruments to conduct this study. It is followed by a detailed description of the study sample and the recruitment process of the participants. Then, I discuss challenges in narrative analysis, interpretation, and representation. The next section continues with narrative discursive analysis and step by step coding process implemented in this study. After briefly discussing ethical considerations the chapter concludes with presenting the methodological limitations.

This research itself has been designed as a narrative performance, because it relies on capturing the lived experiences of the participants, then making meaning of them through both their own words and the researcher's worldviews, and finally presenting them in public. In sum, this entire chapter aims to introduce the reader to all stages and various aspects of my research process.

## 4.2 Research design

The research design is tailored to explore the science identity development of undergraduate, graduate students, and early career researchers in the field of physics and physical sciences in four Dublin universities through the gender perspective. As suggested by Creswell (2003) research design is the plan or proposal to conduct research, and involves the intersection of philosophy, strategies of inquiry, and specific methods. Accordingly, given this definition Creswell notes (2003) that researchers need to think through the philosophical world view assumptions that they bring to the study, the strategy of inquiry that is related to this world view, and the specific methods or procedures of research that translate the approach into practice.

My goal with this research project is to find out how science identities of women, who are at the early stages of their academic career path, are developed and performed in relation to their gender identities. The participants were selected according to their gender identity, which was 'woman', in this case. It was not, however, my intention to categorize or judge the persons based on their gender identity or gender presentation. The gender disparity in science, especially in the fields of physics and physical sciences, was my main concern. As a result, I decided to give women in physics and physical sciences a voice through this research project and speak out about their experiences in these academic fields. Their gender identity (in this case, woman) is purely based on their self-expression and self-identification.

In Ireland where my research took place, figures published by the HEA (2017/18) highlights gender inequality as an issue in the fields of physical sciences, especially in physics, mathematics, and further physical sciences fields. It shows that women are still under-represented in Ireland today within these academic disciplines. This motivates in-depth investigations of issues of science, gender, and identity within these domains.

To deeply explore gender issue in the above-mentioned disciplines the following research questions were posed:

1) How do female students and early career researchers in physics and physical science fields in higher education construct their science identity related to their gender identity?
2) What are the challenges faced by them arising out of incompatibility between gender-science identity?
3) What is the role of the feminist movement on women's science identity development?

In terms of my research, I wanted to give women who are academically involved in science a platform to share their experiences and opinions on what it takes to become a scientific person/scientist/research scientist/science student. I chose to make use of qualitative research methods within this research as I aimed to highlight the perspectives of individual women rather than to produce statistics for the whole population. Merriam and Tisdell (2005) have argued that qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences. In my study, qualitative research enabled me to gain an in-depth understanding of the attitudes, feelings, views, and the real-life experiences of the participants.

## 4.3 Research paradigm and theoretical framework

The philosophical worldview as a general orientation about the world and the nature of research that a researcher holds contributes to the research design (Creswell, 2003). I situated this study within critical constructivism which involved collecting the stories of lived experiences and addressing the conflict, struggles, and power structures in these experiences. This study focused primarily on the following concepts and their inter-relationship:

- Science identity
- Gender identity (with other overlapping identities)

This study particularly applied the critical constructivist research paradigm for the following reasons: First, in the context of this research, identities are viewed to be both socially constructed and influenced by power relations within society and constituted in a social, cultural, and historical context. Science and gender identities of the women who participated in this study were explored as related to a sense of belonging to science (individually), a feeling of belonging to a scientific community, and (scientific) performances. One learns how to be a scientist and to participate in that culture. This learning involves a process of cultural and historical production. Both 'science' and 'gender' identity along with the roles associated with them have evolved throughout human history and evolves throughout one's life. For this reason, I consider identity as a becoming process. In this study, the science identities of women along with their gender identity was interpreted through their perspectives and the researcher's theoretical perspective.

Secondly, I situated my analysis within the non-essentialist perspective using a critical lens consistent with Butler's theory of performativity (See Chapters 2 and 3). From a performative perspective, identity is viewed to open to a continual process of transformation in this research. From Butler's view, the character of identity is never fixed, but always in process. While this study looked at women's science and gender identities in terms of individual and community belonging, as well as performative acts (doing science and doing gender), it also criticized the discourses, social norms, and other social dynamics that make identity categories seem fixed and stable.

However, problematizing that category of identity does not mean to prevent it from being used in order to serve particular ends, but rather to "open it up to the possibility of resignification and transformation" (Webster, 2000 p. 9).

My philosophical stance, in other words, my theoretical perspective, to guide this research is intersectional, feminist, and queer. These theories fed off one another in this study to critique how particular social orders become naturalized and constitute unequal power relations in the culture and practice of science, how such power relations are gendered and affect women's science identity development. These theories served as the bridge between the literature review of this thesis and the empirical data in the sense that they provided a grounding base for my analysis.

I attempted to challenge the boundaries of a 'scientist' and a 'woman' as well as the gendered norms in science by thinking through feminism alongside intersectionality and queer theory. By using these theories both as a theoretical and empirical approach in my thesis, I tried to demonstrate how identities (science and gender identity, in this case) are always 'becoming' according to the standpoint of the individuals. Instead of adopting a single framework, I aimed to use feminist, intersectional and queer theory to challenge the established power-knowledge hierarchies in the culture of science and any stable identities constructed alongside. The intertwinement of feminist, queer and intersectional thinking in this study broadened my understanding of identities and acceptance of multiplicity of them.

### 4.3.1 Feminist theory and its contribution to the framework

The feminist lens applied in this study offers a critical perspective for understanding the gendered social order in the culture and philosophy of science focusing particularly on women's individual experiences.

Ramazanoglu states (2002) that feminist research is politically for women and is grounded in women's experiences. However, I argue that there is no strict definition of who can be identified as a woman, or no solid boundaries of womanhood, femininity, and female identity. This argument is supported by the work of post-structural feminist theorists (Butler, 1988, 2004; Cixous, 1976; Irigaray, 1985; Sedgwick, 1990).

Within the scope of this study, examining the science identity of the participants from a feminist point of view has placed emphasis on how they do science and gender as well as how they practice their science and gender identities. As stated by the participants I interviewed and based on the reports of HEA Ireland there are both 'gender' and 'diversity' issues in physics and physical sciences disciplines in higher education. This research, adopting a feminist theoretical perspective, aimed to make this gender and diversity issue visible by giving voice to female undergraduate and graduate students as well as early-career researchers (PhDs and postdoctoral researchers) coming from different backgrounds in physics and physical science disciplines where women are under-represented. From this aspect, I can say that this is a feminist study that has arisen from the social problem of low participation and under-representation of women in science. However, it was not only the investigation and focus of gender that made this research project feminist, nor a particular method of inquiry I used. As Kelly (1994) argues, what makes research 'feminist' is not the methods that are used, but the particular ways in which they are deployed and the frameworks in which they are located. Feminist research practice can be distinguished "by the questions the researcher asks, the location of the researcher within the process of research and within theorizing, and the intended purpose of the work produced" (Letherby, 2003 p. 5). More specifically, feminist research projects aim to "produce knowledge that will be useful for the effective transformation of gendered injustice and subordination" (Ramazanoglu &Holland, 2002, p. 147).

What makes this study feminist is that it first sheds light on gendered norms that have pervaded science's history, culture, and practice, as well as people's daily social lives, and which continue to influence women. Second, through the interviews with women, this study questioned the certain social and gender roles of women and stereotypes associated with such roles, which could obstruct or clash with their professional (science) identity. I would like to point out that, while this study's emphasis (agent) is on women, the findings can be applied to anybody who does not adhere to gender stereotypes or other prevalent societal norms on their path to becoming a scientist. The feminist lens applied to this study influenced the entire research process from developing the research questions to the analysis of the interviews, interpreting the narratives of the participants, and presenting the results (See Chapter 5 and Chapter 6).

### 4.3.2 Intersectionality and its contribution to the framework

Intersectionality provides an analytical framework for exploring the interlocking and mutually reinforcing intersections of gender, race, sexuality, class, and other social divisions. Besides, it has provided an enormously challenging critique with theoretical and political implications (Sigle-Rushton, 2013) mainly for the feminist and anti-racist scholarship.

I claim that it is useful to examine women's science identity development using an intersectional analysis of gender, class, ethnicity, and other social divisions, because people have different experiences of what it feels like to be socially included or excluded, successful or subordinated, vocal, or silenced (Ramazanoglu & Holland, 2002). Influenced by the Intersectionality, I aimed to see the picture from the unique location of the participants rather than generalize the individual experiences. I believe that women's specific social location shapes the way they talk about the issues, the language they choose, the conclusions they draw.

Feminism focuses on patriarchy and explains gender discrimination by the framework of masculine domination. However, I needed a richer description than such a framework can provide. In this regard, exploring women's science identity from each women's unique standpoint, emphasizing their overlapping identities made my analysis more vibrant and powerful. This way, I was able to see if they have different experiences with science based on their other social identities. In sum, the intersectional perspective in this study provided me multidimensional aspects of identities and subjectivities.

I argue that intersectionality provides analytical benefits to feminist theory. From an analytical perspective, the lens of intersectionality allowed me a) to understand complex social hierarchies across women's experiences, b) to develop an inclusive perspective in order to understand their life, experiences, and positionality within their scientific community. From an intersectional feminist perspective, the narratives of women were analysed both across identities, and multiple and conflicting dimensions of experience (social structures and power relations). From an intersectional perspective, this study aimed to develop new transformative knowledge that allows me to see what might have been marginalized, invisible or misunderstood before (Fraser & MacDougal, 2017).

The focus of this study was on how women's gendered experiences and gender performances could affect their development of science identities. Gender alone offers me a limited understanding of how they build their science identities, their challenges, conflicts, and, more broadly, women's low participation in physics and physical sciences. This way, I aimed to have a comprehensive and deeper understanding of how intersecting identities and experiences of women navigate through the norms and structures of science, especially in the world of physics and physical science.

### 4.3.3 Queer theory and its contribution to the framework

I expanded my theoretical approach to include queer theory to challenge the normative social ordering of identities and subjectivities along a gender binary. In another word, I intended to use queer theory to challenge fixed, restrictive, and binary societal norms, and to discuss "its influences on gender identity, the experience of the self and the shaping of any identity" (Hesse-Biber, 2014, p. 44). The inclusion of a queer in this study did not imply that I would limit my attention to sexual minorities.

Before anything else, queer is a way of thought. Thus, queer theory allowed me to take a critical look at rigid gender categories. It seeks identity construction outside the 'normal' social order and norms. The main target group of this study is still women. Despite the difficulties in establishing what a 'woman' means, I rather not abandon 'woman' as a political category. As Butler (1992, p. 8) has said: "I am not doing away with the category but trying to relieve the category of its foundationalist weight in order to render it as a site for the permanent political contest." This topic has been discussed widely and in detail in the third chapter which I explained gender identity construction and 'woman' as political subjects in (post)feminist movement in science.

In this study, gender identity is viewed as a social construction instead of a personal trait. Thus, I have conceptualized gender as a 'performance' and tried to examine how the participants performed their gender, how that performativity influenced their science identity development and sense of belonging to science.

## 4.4 Researcher's academic and professional background

In this study, I consider my situation both as an insider and an outsider. I am not a scientist, so never have had experience in building up a 'science identity' in the same way as my participants have. As a result, I spent the majority of my time in Dublin reading feminist theory, history, and culture of scientific literature, as well as participating in women in STEM groups.

My interest in the feminist movement and my academic background in Women’s Studies along with my professional teaching career in second-level education led me to this stage. As a teacher, I have seen my students establish assumptions of science professions being dominated by boys. Students’ perception of gendering science results in internal and external barriers towards pursuing STEM studies especially for girls/women and minority groups. My experiences as a teacher who saw students create stereotypical identities from an early age, as well as my philosophical worldview developed primarily by my Women's Studies master's degree, motivated me to develop this study from the research questions to the data analysis and interpretation.

Working as a teacher for almost ten years has also allowed me to cultivate empathy and compassion, as it necessitates one-on-one and group relationships with students and their parents, as well as the ability to see things from another's viewpoint. This sense of empathy and compassion benefited me during the interviews in a way of facilitating the communication between me and the women who participated in this study. My academic background in Women’s Studies shaped my feminist views and led me to question women’s under-representation and low participation in certain scientific fields. However, I think that my personal experiences of this kind have never been reflective in the way that interviews with women could.

## 4.5 Researcher’s position and reflexivity

Reflexivity, as explained by Hesse-Biber (2014) is the process through which a researcher recognizes, examines, and understands how his or her own social background and assumptions can intervene in the research process. In other words, the researcher’s beliefs, attitudes, values, and feelings may affect the research process.

In this study, I examined the individual lived experiences and views of the participants along with their science and gender identity identification, then I made ‘their experiences and views’ academically public. Ribbens and Edwards have claimed (1998) that this is a dilemma that a researcher, as an interpretive authority, experiences: that is, “researching the private and personal, then seeking to voice it in the public” (p. 15). At this point, I, as the researcher, wanted to control my feelings and social identities too much interfering with the interpretation. I also want to emphasize that the researcher’s social identity is not a threat to his/her objectivity. I do not suggest attempting to remove it completely. On the contrary, it is an important part of the research process. However, what I am highlighting is that as a researcher, I tried to identify any possible subjective thoughts and biases which might be derived from my own identity, background, or worldview and to control the possible effects of them.

Throughout the preparation of conducting this research, from the formulation of the research questions to choosing in-depth interviews as my research method, from analysing and interpreting the narratives of women to presenting them and making them academically public, I have been aware of my positionality as a Ph.D. woman researching feminism and queer issues and actively engaging in feminist activist movements for several years. Besides, unlike my participants, I have developed an intellectual and academic distance from specific science subjects since elementary school. As a result, I had no experience cultivating a sense of belonging to specific physical science domains. Furthermore, I have had significant apprehensions about even grasping the fundamentals of physics.

Rather than focusing on my own positionality, I embarked on this study with the aim of better understanding the perspectives of my participants. To avoid overshadowing the participants' voices, I sought to remove my own bias and subjectivity before entering the study process. When representing the voice of my participants, however, I have not fully removed the influence of my subjectivity.

This study gave voice to the multi-layered voices of women in physics and physical sciences in higher education as participants, as well as the voice of my ideas and thoughts as a researcher who wanted to bring the gender and diversity problem in the aforementioned academic fields in Ireland to the public's attention.. In this sense, I consider this research to be a collaborative study, but at the end of the day, this is more a study of and for women in science.

## 4.6 Research approach – Design of case study

I used a case study approach to explore the ‘science identity’ development of undergraduate, graduate students, and early career researchers in the fields of physics and physical sciences in higher education through the gender perspective. This case study arose from the real-life sociological issue of women’s lower level of participation in science, especially in the fields of physics and further physical sciences in Ireland (HEA, 2017/18) where this study took place.

The case study approach was adopted in this project for the following reasons: It provided a focused, in-depth, and detailed study of individuals. Merriam and Tisdell (2005) have defined a case study as an “in-depth description of an analysis of a bounded system” (p. 37). Yin has emphasized the importance of real-life context in his definition. According to him, case study research is an “empirical inquiry that investigates a contemporary phenomenon within its real-life context” (Yin, 2009, p.18). In this study, the emphasis was not to measure, provide statistical information or make predictions, but to achieve an in-depth understanding of a gender - science issue through individual experiences of women in the above-mentioned disciplines. Using a case study with individual in-depth interview method in my research has facilitated a much deeper probing into the lived experiences of female science students and researchers, and how they constitute their own identities in relation to these disciplines, its norms, and expectations.

This research used an embedded single-case design because there were three units which I focused: (1) women’s science identity development in relation to their gender, (2) women's challenges in their respective academic fields, (3) the influence of the feminist movement on women’s science identity development. In embedded single-case design, the single case study may involve more than one unit of analysis (Yin, 2009). He further states (Yin, 2009) that the subunits can often add significant opportunities for extensive analysis, enhancing the insights into the single case. In this study, investigation of ‘science identity’ development of women constitutes the main of analysis, while their challenges in their respective academic fields and the influence of the feminist movement on their science identity formation constitute the sub-units of analysis. It is essential for women to build their science identities and gain agency through their experiences if they are to engage deeply with science and eventually pursue scientific careers.

I decided to use a single case study rather than a multi-case design. The reason for this is that although single-case designs are vulnerable because “you will put all your eggs in one basket” (Yin, 2009, p. 61), single-case was more appropriate for my study, as I wished to “understand the particular in-depth, not to find out what is generally true of the many” (Merriam & Tisdell, 2005, p. 254).

The boundaries of the case are geographical, temporal, and demographic: geographically the cases bounded by the four universities in Dublin area: Trinity College Dublin (TCD), University College Dublin (UCD), Dublin City University (DCU), and Technological University Dublin (TU Dublin). Specifically, UCD School of Physics; DCU School of Physical Science; TCD School of Physics, TCD CRANN Research Institute, TCD AMBER Centre, TCD ICRAG Research Centre; TU Dublin School of Physics & Clinical & Optometric Sciences, and TU Dublin FOCAS Research Institute were included.

The disciplines of physics and physical sciences have been determined according to HEA (2017/18) statistics of a new entrance, enrolments, and graduates by level, the field of study, and gender. First, the number of disciplines in the field of science where the rate of women's participation is comparatively lower was identified based on the figures of HEA. Within the scope of this research, only the academic disciplines of science at the university level which has the lowest women's participation were listed and included in the case: physics and physical science disciplines.

There are four large public research universities in Dublin city where this research was carried out: TCD, UCD, DCU, and TU Dublin. Including these universities, I also aimed to see if there were discrepancies between the universities with regard to how students and researchers view science and develop their science identities.

The cohort, in this case, was taken from women enrolled in physics and physical sciences disciplines at bachelor's and master's, Ph.D. and postdoctoral level in TCD, UCD, DCU, and TU Dublin. My emphasis was on the women who were at an early stage of their academic careers because there are many leaks in the pipeline in this population according to the data report carried out by UNESCO (2015) which shows educational pipeline rates of women in science in Ireland. Also, according to a Study of Progression in Irish Higher Education (2014/15 to 2015/16), higher education dropouts and switching careers mostly happen in the early years of the education or career. I aimed to find out how the 'science identity' of women in their early (academic) career years in higher education impact on their sense of belonging in science and progressing in this field.

Demographically it was intended to include female students and researchers from diverse backgrounds in terms of country of origin, age, ethnicity where possible. My main aim was to capture diversity in the target group in order to see if they faced any barriers in science based on multiple overlapping social identities of women. Temporarily, the case was bounded by the years 2019 to 2020.

However, further longitudinal research might be done a few years later with follow-up interviews with the participants to see how their meanings of science and themselves as a scientist evolve in time.

One recent example of a case study of the relationship between science identity and sense of belonging conducted in Ireland could be a study of Mooney et al. (2018). They conducted mixed-method single case research to investigate the role that gender plays in deciding to study Computer Science at University College Dublin in Ireland. The study has revealed significantly lower levels of sense of belonging reported by female students providing a cause for concern considering the link of sense of belonging with progression in higher education and general well-being (Mooney et al., 2018). This study is informative in terms of determining whether there is a difference in the sense of belonging between the genders through the example of one Irish university. However, it did not provide me with the compelling reasons for a lower sense of belonging of female students in science.

Most of the research done on science identity with a gender focus is longitudinal studies where the researchers obverse identity process of the participants over years (Carlone & Johnson, 2007; Cole & Espinoza, 2009; Stets et al., 2017; Brainard & Carlin, 2013; Wiliams & George, 2014). Common for these studies is a focus on the science identity performance of women and/or minority groups in third-level education. These studies have revealed some findings of the interrelations of self-efficacy, self-belonging, and science identity development of women which in the end highlights the issue of low representation of women in science. My study, on the other hand, looks at the same issue from the broader historical and sociological perspective by questioning the social norms which constitute 'woman' and 'scientist' as two opposite categories.

I would like to draw particular attention to a longitudinal single case study of a woman called Sara, who previously considered dropping out of high school, then developed a strong science and mathematics agency through her experiences in high school science and chose a chemical engineering major in college, but completely lost her interest and finally left the college (Godwin & Potvin, 2017). This case has attracted my attention in the way that Sara first developed a critical science (STEM) identity and experienced a “disconnect between her developed identity and empowerment over time” (Godwin & Potvin, 2017, p. 446). The study of Sara showed me a strong connection between belonginess and STEM identity and how a STEM identity can change in one’s early academic career life. This story of Sara has some similarities with my research as the focus is on the science identity development of a woman from secondary education to early career years in college, her motivation, and her self-interest in STEM. In my study, I did not specifically focus on second-level education science. However, during the interview, I aimed to ask questions about the participants' previous studies in order to get a clearer image of the situation, because high school science education is an important step toward deciding on a university science major.

Godwin et al. (2017) study is based on Sara’s own narration of her science identity and her experiences in STEM. However, there is no relevance here between Sara’s science and gender identity. The emphasis is on the school, teacher’s support, and the content of the course. My study, on the other hand, focused on the relationship between gender and science identities among women in science, as well as other overlapping identities.

## 4.7 Data generation instruments

In order to explore empirically female students’ and researchers’ constitutions of science identity in relation to their gender identity, I choose to do semi-structured in-depth individual interviews to generate the data required to answer the research questions.

I chose to do interviews because of the following reasons: Firstly, I am particularly interested in data storytelling, in other words, narrative aspects of data generation in order to understand people’s thoughts, experiences, and self-evaluations. Thus, narrative interviewing has been deemed suitable to gather the data as my study focuses on how women talk about and evaluate their science identity through gender perspective along with their experiences in the field of science. In this sense, narratives can be viewed as a window into the process of identity construction. While I use the term ‘interview’ as a conversation between me and the participants, narratives are used as specific stories within an interview.

Secondly, the aim of this study was not to reach generalized results but to investigate deeply participant’s own views and thoughts on their science identities in relation to their gender identity. Rather than trying to find “universally generalizable themes, I preferred to offer insights, glimpses into others” worlds and ways of seeing the world’ (Fraser & MacDougal, 2017, p. 249).

Narrative data provides for clarification, understanding, and explanation – not for generalizing (Renner & Taylor-Powell, 2003). However, there are transferable implications of each participant’s story. Besides, each personal narrative has a link to a broader narrative and gives us insights into a wider social, cultural, and political context. In this sense, interviewing suits this research best as it both provides a rich understanding of one’s identity construction from each participant’s perspective and their voice and illustrates the broader socio-cultural practices of the science community. Although I do not aim to reach a big generalized result, I am interested in collective aspects of women’s personal stories, because it enables them to have a voice in society if they experience marginalization and/or barriers.

According to Lawler (2002) “narratives are not only produced by individuals but also circulate socially” (p. 251). Lawler (2002) further adds that the narratives are social products produced by people within the context of specific social, historical, and cultural locations. In other words, she argues that “not only do people often produce storied accounts of themselves but also the social world itself storied” (Lawler, 2002, p. 242). Therefore, narratives within the interviews, in this research enabled me not only to investigate each participants’ ‘science’ and ‘gender’ identity formation just the way they individually structured them, but also investigate the ‘power mechanism’ behind identity construction of women in science embedded in a social, political and cultural context.

In this study, the interview was viewed as an interactive social process achieved by a researcher and a participant by giving meaning to the information produced. Yin (2016) mentions that qualitative research interviews present the opportunity for two-way interactions. I chose to do face-to-face in-depth individual interviews. The individual interview has the advantage of letting the participant talk about potentially personal sensitive issues on one-on-one conversation, and of going much deeper into the particular case. Such an interview in this study aimed to deeply understand women’s self-perception and evaluation of their own science identity in relation to their gender. It is important in this study that women tell their ideas, thoughts, and views in their own way “rather than restrict them with close and rigid questioning” (Reinharz, 1992, p. 25). Thus, I preferred ‘semi-structured’ or ‘open-ending interview’ which consists of open-ended questions to “maximize description and discovery” (Reinharz, 1992, p. 19).

This study emphasized the interactive and communicative aspects of data generation because, in this research, identities were co-constructed by the participants and the researcher, especially at the interpretation stage. This study’s focus was not only on what women said about their identities but also on how they talked about their identities.

I purposely preferred interviewing the participants separately, so that a response by one participant did not affect other people’s responses. In this respect, one-on-one interviews both allowed personal contact and privacy between the participants and me. It also fostered communication and kept the process active.

The length of the interviews depended on the flow of the conversation. Approximately, the interviews lasted between 45 minutes and one and a half hours. I prepared some questions to guide the interview and organized them under key themes addressing the research questions. The themes are as follow:

a) Biographical background
b) Identifying as a scientist
c) Understanding gender
d) Struggles and challenges

Some general questions were added in case I needed them according to the flow of the conversation and some more questions were also prepared specifically for postdoctoral researchers. The questions of the categories above were arranged in order but reformulated as the participants' and researcher's wish during the interview. All in all, each story was unique and had its own dynamics and flow. For that reason, I did not intend to strictly follow a formalized interview template to fit each participant. Instead, although I wanted to use them to guide the conversation, I developed some new questions depending on the flow of the conversation.

The interviews which were audiotaped started with a discussion of the participants' early interest in science, their early motivation to pursue a scientific career, then segued into questions about their present experiences in the class, lab, research group, their attitudes in physics and physical sciences, their perception of a scientist, their evaluation of gender and science identity, future career plans, their attitudes to the feminist movement in science and finally a general discussion on being a woman in science, - struggles, conflicts, challenges-. Thirty women chose to participate in the interview. However, twenty-nine narratives were included in the analysis stage. One of the participants wanted to meet at a café at her lunch break, but the background noises were so loud that I could not hear our voices clearly when I tried to listen to the recording later. The quality of the recording was very low. So, I decided not to include that interview in the analysis process.

At the time of the interview, the participants were all enrolled in undergraduate, graduate, and postdoctoral programmes. The interviews started in early March of 2019 and finished in the last week of May in 2019.

## 4.8 The sample frame

My research questions required representation from female students and early career researchers in the fields of physics and physical sciences. In this sense, the sample in my study included women enrolled in physics and physical sciences disciplines in TCD, UCD DCU, and TU Dublin as undergraduate and graduate levels as well as early career researchers such as Ph.D. and postdoctoral fellows. I aimed to look at each study /career level in physics and physical sciences in higher education in order to see if the women who participated in this study's attitudes and self-identification with science changes depending on their academic level. Also, I wanted to see 'science identity development' in the process. As my study was not a longitudinal one in which I could observe the 'development of science identity' over a time period, I decided to include each study/early career level so that I could see the identity development 'in process' in at a single point in time. Rather than conducting repeated interviews with the participants over the years, I decided to do one interview with the participants at different study/career level. In that case, the structure of the individual interviews was cross-sectional. Looking at each level (BA, MA, Ph.D., and postdoc) at the same time allowed me to see the 'identity development process' over a short period of time.

In order to see the diversity in the group of participants, I aimed to have the representation of women by race, ethnic background, social class, where possible. I chose a women-only respondent group, but 'woman' is also a controversial term in this study as previously explained in my literature review chapter (See Chapter 3)

The logic of qualitative research is concerned with in-depth understanding and usually involves working with small samples (Hesse-Biber, 2014). The sample included twenty-nice participants from undergraduate to postdoctoral from Dublin universities. I wanted to see if the participants' perception of science identity differs at different academic degree level.

The main aim of this research was not to represent the whole female scientist community or to reach big data to make a generalization. The focus was on having a rich and deep understanding of the selected participants' perception and performance of science identity in relation to their gender. Thus, I focused on the views of fewer people in greater depth.

This study used both purposive and self-selection samples. It was purposive because the selection of the participants was based on the objective of the study. As explained by Yin (2016) the goal or purpose for selecting the specific instances is to have those that will yield the most relevant and plentiful data. Thus, the selection of the participants was strategic for me. I prepared an email template with a link to a Google Form and a participant recruitment poster which I specifically highlighted the certain criteria of the required participants. Criteria for participation were female students and early career researchers who enrolled in physics and physical sciences departments as bachelor's, master's, Ph.D. or postdoctoral level in four Irish Universities: Trinity College Dublin, University College Dublin, Dublin City University, and Technological University Dublin. TU Dublin was later included as it was established as a university in my second year of Ph.D. The sample is self-selective because only women who fall into the category above, and who expressed an interest to participate in this research were invited to be interviewed.

I decided to recruit women by putting up signs around the TCD, DCU, and UCD campus asking for volunteers; getting contact with the school administrations as the gatekeepers in science faculties and departments in TCD, UCD, and DCU, providing an explanation of the research and asking permission for reaching the students and staff; and contacting with my social network, colleagues and friends to recommend participants for the interview. Once I prepared a Google form and a poster, I attached them to my email which I sent out the above-mentioned departments and schools. Later, I followed the same process for recruiting interviews from TU Dublin.

The Google Form was created to gather information from the participants who showed initial interest in this study. The Google form included three sections: In the first section it was provided brief information about my research, the second section asked participants' personal details (name, gender, email, phone) and the third section asked their academic details (institution, the field of study, academic level/degree).

I received a quick response from DCU School of Physics, TCD CRANN Research Institute, TCD School of Physics, UCD School of Physics, and UCD Women@STEM group. They circulated my e-mail to their members, departmental staff, research fellows, and faculty students. Besides, UCD School of Physics printed and placed the poster I prepared to recruit participants up in their building for the attention of students and staff. Most of the women who completed an expression of interest form (Google Form) or who directly reached me via e-mail were undergraduate students and Ph.D. researchers from the School of Physics in Trinity and researchers from CRANN Institute. Thus, I sent a second notification to UCD contacting directly to the programme directors. As for DCU, the participants were mostly undergraduate students at a range of different levels of academic courses in the School of Physical Sciences. So, I sent another email to the school administrator asking for researchers' contact details.

In the second year of my research, my supervisor and the reader in my Ph.D. confirmation suggested that I could include Technological University Dublin (TU Dublin) which officially came into being just on January 1st of 2019. Right after the confirmation, I contacted the School of Physics and FOCAS Institute of TU Dublin. Participants from TU Dublin were recruited from e-mail.  I sent an e-mail to the head of the school and PIs of the research groups of TU Dublin Physics school. I got a quick and warm response from them. Finally, several undergraduate students and two postdoctoral researchers agreed to participate in the interview. I only included one undergraduate student from the Physics department of TU Dublin and one postdoctoral researcher from the FOCAS Institute. The other students who reached to me were from various science fields, which was not specifically physical sciences. One of the postdoctoral researchers was interested to participate in the interview but she disagreed with the recording, so I had to remove her from the sample because without recording it would be too difficult for me to provide a meaningful unity of the narrative.

I also contacted WITS Ireland (Women in Technology and Science) of which I was also a member. They included a note in their March 2019 newsletter about my research project and shared the poster on their social media. Also, after I posted the recruitment poster on Twitter, a postdoctoral researcher from the ICRAC Centre reached me via e-mail. She also wanted to participate. She was the only representative participant from ICRAC Centre (Applied Geosciences) which is a physical science domain. I was hesitant to include her at first because no one from the Geoscience department had contacted me for the interview. Then I decided to interview her because she was in the scope of my sample frame, she was very eager to participate and share her experiences. I also needed more samples from postdoctoral researchers. During my participant seeking process, I realised that women at the graduate level are quite low in the physical sciences, especially in the field of physics. Women’s participation in the postdoctoral position is even lower. For this reason, I made an extra effort to find women in the physical sciences at the postdoctoral level who might be interested in my research topic. After I interviewed with some of the Ph.D. students, I kindly asked them if they knew any female postdoctoral researchers in their departments. This way, I managed to contact two postdoctoral researchers. Also, after I interviewed with a postdoctoral researcher in the School of Physics in TCD, she provided me with her colleague's email and mentioned about my research. Through her, I contacted her colleague and arranged a meeting time.

The majority of the women at the undergraduate and postdoctoral levels who were interested in participating in the interview were from various subfields of physics. That made my sample population heavily representative of physics. At a master's level, only two women reached to me, one of them was from Energy Science and the other was from Space Science. At the Ph.D. level, the majority of the participants came from a number of physics backgrounds, but a few of them later turned to physics after obtaining a bachelor's degree in chemistry or engineering. They came from a variety of academic science backgrounds at the post-doctoral level. All of them were engaged in various physical science projects at the time of the interview. All the participants studied physics and mathematics at various stages of their academic careers.

## 4.9 Data analysis technique

Data analysis is a process of "envisaging patterns, making sense, giving shape, and bringing the qualities of material under control" (Ramazanoglu & Holland, 2002, p. 160). In this study, the material involves interview transcripts.

The data are neither "lying around waiting to be collected" (Ramazanoglu & Holland, 2002, p. 160), nor "speak for themselves" (Yin, 2016, p. 221). Especially at the interpreting stage, the researcher gives meaning to both the words and non-verbal gestures. This is also where the researcher puts his/her reflexivity into practice.

This study, as already mentioned, used in-depth semi-structural individual interviews as its primary sources, which the participants told their own stories with their own words. This study used discursive narrative analysis that focused on: (a) narrative analysis of women's experiences and stories related to their science and gender identities, (b) analysis of discourse and subject positions based on commonly emerging themes. The discursive narrative analysis emphasizes detailed analytic procedure which includes looking common elements that occur across different interviews, also at different points in the same interview (Taylor and Littleton, 2006).

I chose to analyse their gender and science identities through one version of narrative analysis which deals with the discursive and performative dimension of the narrative as described in Taylor and Littleton (2006). Derived from discursive psychology, (Taylor and Littleton, 2006) "meanings are constructed, carried, and modified in talk and interaction" (p.24) I employed a discursive narrative analysis for the following reasons.–Firstly, as it focuses on the interactive context of the interview, performance of identity, and a detailed examination of the talk (Taylor and Littleton- 2006). This way, both I, as the researcher, and the participants would have an active role in terms of constructing the identities and giving meaning to them. Besides, discursive narrative analysis is in line with the theoretical perspective of this study. From a feminist perspective, I claim that women's narratives are not only derived from their experiences but also, they are produced in social, historical, and cultural context as well as by the teller's and listener's positioning. In other words, as mentioned by Riessmann (2008) the narrative becomes a narrative with the reader, listener, audience in a particular context, and shaped by their interpretation. She noted (2008):

> *Stories do not fall from the sky. They are composed and received in context-interactional, historical, institutional, and discursive. Stories are social artefacts, telling us as much about society and culture as they do about a person or a group (p. 105).*

This way, discursive narrative analysis of women's experiences also kept me alert to my role as a socially positioned listener of stories, and researcher in the interpretation of women's stories. Furthermore, a narrative-analysis approach helped me to focus on how women talked about their perception of science and gender identities by "constructing dialogues with the key characters in their lives and giving them positions and motives in the unfolding stories" (Elliott, 2005; Riessman, 2008).

There are two stages of analysing the data. In the first phase of the analysis process, my main focus was on analysing the participants' self-understanding of their identities as a scientist, their perception/performance of gender identities, and their experience in the class/lab/research groups/scientific community. In the second stage of analysis, my focus shifted from individual participants to how they as a collective group can be understood as constituting their science identity in relation to their gender. The reason behind these two different stages of analysis is that identity is formed both in a personal and social context (Stets & Burke, 2000) because individuals can do and act as individual persons and social groups. In this regard, self-recognition of being a scientist is as important as being recognized as a scientist by other people and the community. For this purpose, I decided to analyse the 'science identity' of women who participate in this study from the self and social (collective) identity perspective. Such analysis aims to create a rich and explanatory description of the data.

I would like to stress that I, as the researcher, did not simply formulate the stories presented by each participant. I re-told their stories through my theoretical perspective. In this regard, the research questions guided the process of data analysis, while the theoretical framework was used to make meaning of the participant's experiences. There was a mutual interaction between my literature review and my analysis process. I completed most of my literature review section before the interviews. My literature review on science and gender relations provided me a perspective during analysis process. Especially the science identity framework explained in Chapter 2, illuminated the way I interacted with the participants' narratives. However, some sections of the literature review were shaped both during and after the analysis process. The construction of a physics identity and the masculine nature of physics and the physical sciences were added after the analysis process. Overall, the literature review presented in this study, particularly previous studies on science and physics identity construction served as a helpful guide for me as I attempted to comprehend and interpret the women's narratives.

The analysis part of this research largely included the participants' experiences and views which predominantly highlighted their voices. In the discussion part, I heavily relied on my theoretical framework to interpret the narratives.

### 4.9.1 Objectivity in data analysis

In order to establish credibility of the data generated and of the subsequent result, I took several steps to raise my level of awareness and knowledge about gender and science from both local and global perspective: I conducted an in-depth literature review that were back research up in gender and science relation. I also participated in women in science groups, science events in Dublin to gain a local perspective about women's science identity development, their challenges as students and researchers as well as to keep up to date about the latest issues and recent developments in science within Irish context. I joined WIRI (Women in Research in Ireland), WITS Ireland (Women in Technology and Science), VoYS (Voice of Young Science) Standing up for Science workshop which took place in Dublin and science weeks events in my first year of PhD. I shared my knowledge and experience with my supervisor in our monthly meetings.

While I was doing the interviews, I was continuously in touch with my supervisor and let him know each step I took. After I coded the transcribed text and identified the themes, I shared it with my supervisor in order to gain a different perspective. Besides, throughout the research process I have also shared my findings and analysis with my research colleagues and in the PhD conference that we held in every year in the School of Education. I also participated in ESERA virtual summer school while I was in the process of writing my findings and discussion part. I introduced my study and discussed results with other PhD students in our study group and two professors in science education. I also presented an earlier version of my analysis at a virtual meeting in Brazil with two professors and a group of PhD students in science education. This meeting was arranged one of my colleagues from Brazil who is in science education and got interested in my research. She kindly asked me to show my earlier findings to her study groups and superiors. This continuous process of sharing and discussion has given me much useful feedback which enables me to reconsider critical aspects of my research. Finally, I included lengthy extracts from the interviews together with full description of the data generation and analysis process in my thesis in order to ensure transparency and credibility.  Notwithstanding, I acknowledge that it is unlikely to provide complete objectivity in qualitative research and I am always conscious of my subjective opinions and viewpoints. this can be considered as a limitation of discursive narrative research that I used to analyse the data

### 4.9.2 Coding and analysis process

With regard to the process of analysis, the first step was to transcribe the recorded interviews.  I chose to transcribe all my interviews myself in order to hear the participants voice once again and coded the data myself instead of using a coding software. It took two months for me to finish transcribing.

First of all, each transcript was read as a story in order to become acquainted with the transcript set as a whole. At this stage, I began constructing the participants' profiles which shed light on participants' prior experience with science before college and give a general overview of their academic background. The purpose of constructing the individual profiles was to introduce each participant before deeply analysing their experiences and views in order to emphasize the contingent and contextual nature of the narratives.

Then, in order to find the themes, I re-read each transcribed narrative carefully line by line. In the re-reading phase, I kept in mind my research questions and key points that I wanted to reach: participants' science identity development related to gender, their challenges at the intersection of their gender and science identities, and the role of the feminist movement on their science identity development. I also paid particular attention to how participants build their science identity from individual and community perspective. Here, my goal was to examine the content of the narratives and to recognise common thematic elements in each narrative.

I chose to identify the themes by using lexical items, phrases, and overarching themes as described by Baxter (2003). Baxter (2003, p. 138) suggested four elements for discourse identification: (1) words, terms, and phrases commonly used by the participants, (2) commonly emerging themes, (3) connections, links, and associations in what participants say (4) contradictions, oppositions or competing views in what participants say. Thus, I paid attention to the common issues, terms, words, discourses and phrases that participants stressed and repeated most throughout the narratives and also which I believe are significant based on the literature review. At this stage the codes were allocated to the frequently used words, phrases and statements across narratives. The themes were emerged when I listed all the codes in a word document. I created themes by bringing several codes together. Once again, I read the text and this time I colored each theme with different colors so that I could find them easily when putting them into words.

The codes and themes are displayed in the table below.

Table 4. 1 Codes and themes

| **Color** | **Theme** | **Codes** |
|---|---|---|
| | Sense of belonging to science | enjoying maths, interest/enjoying science, competence, sense of community, sharing, intersecting identities |
| | Doing science | scientist-me, scientist-stereotype, scientist-characteristic, physicist identity, scientific activities, strong physicist woman, nerd, physics |
| | Doing gender | gender-personal, gender-fluid, feminine/masculine, femininity and science |
| | Struggles | maternity/childcare, academic instability, confidence, sacrifice, bias, drop-out, proving, role model, family/responsibility, gender role belief, numerical /normative male dominance |
| | Visibility and women's network | feminism, equality, networking, visible |
| | The discourse of 'women in science' | women in science, labelling, gender quota |

When I built the themes, I also paid particular attention to my research questions, my literature review and science identity framework. For example, the themes *sense of belonging to science, doing science, and doing gender* are in line with my science identity framework for this study. I aimed to look at the factor of belonging and performance (doing science) in constructing women's science identity development. Thus, I used these themes to answer my first research question which I focused on science identity development of women from a gender perspective.

The theme *Struggle* was built in accordance with my second research questions which centered on the challenges of women faced at the intersection of their gender and science identity. I therefore coded the words, phrases and discourses that were linked to the difficulties they faced during their academic life. By bringing the codes together I created the theme 'Struggles'.

The themes *visibility and women's network* and *the discourse of 'women in science'* matched with my third research questions which I investigated the role of the feminist movement on women's science identity development. The codes that emerged related to the feminist movement and feminist identification were grouped together first. I then looked closely at these codes and identified two themes, one of which referred to the 'women in science' labelling and the other related to the movement's impact on women scientist.

When I built the themes, I then interpreted the codes under each theme if I could find any similarities and differences among them. I worked one by one through them and I wanted to create sub-themes if under each theme the codes bear a certain significance different from the other codes. For instance, the identity of the physicist seemed different from that of the scientist. So, for each of them, I created a subtheme. Sub-theme *I am not a typical physicist girl* under the main theme 'doing science' also seemed distinctive to me. The code *strong physicist woman* became *I am not a typical physicist girl* subtheme.

Another example is that four challenges were described under the theme *Struggles,* which were different from one another. So, for each of them, I created a subtheme.

The table below shows all the themes, subthemes and the codes attached to them

Table 4. 2 Themes, subthemes and codes

| **Theme** | **Subtheme** | **Codes** |
|---|---|---|
| Sense of belonging to science | Emotional attachment to science | enjoying maths, interest/enjoying science, competence |
| | Community attachment to science | sense of community, sharing, intersecting identities |
| Doing science | Constructing the boundaries of a scientist | scientist-characteristic |
| | The stereotypical image of a scientist | scientist-stereotype |
| | Scientist versus physicist | physicist identity, physicist |
| | No more stereotypical image | scientist-me, scientific activities |
| | I am not a typical physicist girl | strong physicist woman |
| | The 'nerd' image | nerd |
| Doing gender | It is my personal journey | gender-personal, gender-fluid, |
| | Girly girls& tomboys-girls doing femininity and masculinity | feminine/masculine |
| | Negotiations of femininity in science | femininity and science |

| | | |
|---|---|---|
| Struggles | Maternity and child-care | maternity/childcare, academic instability, sacrifice, gender role belief, family/responsibility |
| | Low level of self-confidence and imposter syndrome | confidence, bias, drop-out |
| | Anxiety of proving | proving, confidence, normative male dominance |
| | Limited or lack of female role model | numerical male dominance, role model |
| Visibility and women's network | | feminism, equality, networking, visible |
| The discourse of 'women in science' | | women in science, labelling, gender quota |

## 4.10 Challenges in interviews, analysis, interpretation, and representation

In recent decades, scholars from a wide spectrum of disciplines suggest that we live in a story-shaped world (Lawler, 2012; Rosenwald & Ochberg, 1992; Sommers, 1994; Kearney, 2002). They claim that humans make sense of the world through narratives, and identities are narratively and discursively constructed. As argued by Rosenwald and Ochberg (1992) personal stories are not merely a way of telling someone (or oneself) about one's life; "they are the means by which identities are fashioned" (p.1). Similarly, Somers (1994) says that "it is through narrativity that we come to know, understand, and make sense of the social world" (p. 606). In this study, it is important to note that identities are not considered as foundational and essential categories, but "something produced through the narratives people use to explain and understand their lives" (Lawler, 2002, p. 250). Thus, identities have the potential to transform, change throughout the life span as well as throughout human history. In this study, only a particular length of time was captured in participants' narratives. The future evolution of the participants' science identities is always an open-ended process.

I have long been interested in women's writings and narratives. As a researcher, I believe the political significance of how women construct, perform, and negotiate their gender identities along with their other social identities through the event of narration to transform the social order. Thus, I decided to bring their voices and personal experiences in the research process. However, there are some challenges especially in 'speaking for' when it comes to representing. While narratives describe the participants' stories, it is the researcher who decides how to translate the stories, what stories to include, and how to edit and organize the final product (Chase, 2011). My position as a researcher shaped from the analysis of the narratives to the interpretation and representation of the narratives of women.

During my study, I encountered the following five challenges: 1. the definition of 'woman,' 2. discrepancies among women, 3. the boundaries of 'science' and 'gender identity,' 4. interviewing with women (whether I asked the correct and meaningful questions or not), 5. my worldview interfering too much with the research and interpreting phase

At this point, first, an intersectional and queer perspective, enabled me to recognize multiple forms of identity that can be read through discursive practices and performances. Second, through the analysis of the interviews, I realised that what it means to be a scientist and to be a woman is quite subjective. The boundaries of individual and collective identities of 'scientist' and 'woman' are discursively constituted and performed which, in other words, are always in process. As explained by Yuval-Davis, (2011) "narratives of identities can be more or less stable in different social contexts, more or less coherent, more or less authorized and/or contested by self and Others, depending on the specific situational factors, and can reflect those of significant moments of crisis and transformation" (pp. 14-15). In this study, I positioned identity primarily in relation to a sense of belonging and performance. I acknowledge that both a sense of belonging and performances can be fluid, relational, and depending on particular situations.

The influence of post-feminist and queer methodological principles that I adopted, shaped the analysis, interpretation, and presentation process. This made me think whether my participants had the same feminist and queer agenda as me, and whether they agreed with the results of my report. Throughout the entire research process, the two keywords that were used to manage these topics were transparency and empathy. Rather than forming the narratives solely from my worldview, I attempted to represent the narratives from the perspectives of my participants through my analytic analysis.

Throughout both the theoretical and practical (interviews) parts of this research process, I was more concerned about the social norms, discourses, and roles that lead to social injustice and inequality. I sought to challenge these social norms both in the culture of science and gender which normalize and homogenize certain practices, roles, and knowledge. Especially through the interviews I sometimes thought that what I was seeking to challenge may not be something which needs to be challenged from the participants' point of views. Perhaps these social norms have become so naturalized and internalized that they have become an integral part of their identity. It could be as if questioning and challenging these norms is equivalent to questioning and challenging one's own self. I thought there is a thin line between attacking to one's identity (or ontological status- self) and criticizing it, as well as the essentialism that surrounds it. During the interviews, I avoided asking questions that directly target their identities, instead, I referred to the power dynamics that underpin the 'identity'.

## 4.11 Ethical consideration

As a part of this study, I conducted in-depth individual interviews with women. Before I started interviews, I thought it would be the most difficult part of this research as I did not conduct any research interviews before, and I was not sure if I could develop a well-balanced relationship with the participants which was based on mutual respect, understanding, and trust. Thus, I took various measures to follow the research ethics principles which I thought would ease the process. These measures are outlined in the following:

I prepared participant consent forms and information sheets to give the participants before each interview. The participants signed the consent form at the end of each interview. I also prepared an email template that I sent out after they had filled in the Google form. This way I informed them about the nature of the research and the interview and made assurances that their confidentiality would be protected. These measures were implemented from the research ethics principles which adhere to Trinity's Policy on Good Research Practice. However, just after the first interview, rather than simply following the protocol, I understood that this was an emotional sharing and intimacy. They were interested in my research topic and tried to help as much as they could by being open, cooperative, and supportive. I noticed that we were all women who were uncomfortable in some way with male privilege in all aspects of daily life, from societal expectations to gender role beliefs. I was sometimes aware that my gender understanding (concept) differed from that of some of these women, and I was more skeptical of my gender identity. Other times, I felt that in order to alter the unequal system, we needed to connect and support one another. The interviews were much more like friendly conversations founded on mutual trust, sympathy, kindness, and understanding as a result of this feeling.

After each conversation, I felt like our conversations were more like sharing our thoughts and ideas. Since I am not a scientist, I paid more attention when we were discussing science. However, when it came to gender expressions, roles, sexuality, and gender identity, I participated more and shared my opinions. Overall, rather than the conventional way of formal interviewing, the interactions between me and the women were informal and based on mutual sharing and cooperation.

I approached my relationship with women with the aim of listening, learning, and understanding. As the research involved examining issues that could be sensitive to the participants such as gender identity, gender expression, and roles I gave them full reassurance that responses would be reported in such a way that could cause individuals to be identified.

The negotiation of gender identity may be considered a sensitive topic. Before each interview, I assured the participants that they did not answer anything they were uncomfortable answering, and they did not have to give any reason for doing so. However, I did not observe a sign of distress and discomfort from the women I interviewed.

Even if they were not explicitly mentioned in my interview questions, I encouraged the participants to speak about the topics that were important to them. Instead of expecting answers to my interview questions, I learned more from them by listening with empathy to stories from their world. I was conscious of the fact that opening up these kinds of spaces during the interview by letting them talk about the issues they wanted even if they were not included in the interview questions reinforced dialog between us.

## 4.12 Methodological limitation

There are some limitations of this research that are explained in this section. First, given the qualitative and narrative nature of the study and in-depth interview method, the number of participants is relatively small. However, the rich and in-depth descriptions provided across the narratives allow the readers a better understanding of the experiences of women that contributed their engagement and progression in physics and certain physical science domains. The readers were provided a rich narrative data from the participants' lived experiences by their own words and from their perspectives. However, the sample was limited to 29 women, so the results are not expected to be generalizable to all-female physics and physical sciences students, graduates, and researchers. However, the readers can gain a profound insight into certain aspects of their lives, which they can generalize themselves from. The readers may find similarities between the participants' and their own experiences or they may gain insight and awareness of the lived experiences and perspectives of the participants' described.

Second, while there were a few participants from an underrepresented minority background such as sexuality, ethnicity, religion (different than dominant scientist population) involved in the study, the participants were by no means a representative population of scientists. Ireland is relatively a small country. The research only took place in four Dublin universities and was limited to physics and physical science departments. It only reflects a small part of the big picture. Although intersectionality was included in my theoretical perspective, the sample was more homogenous than I expected. For example, there was not much difference among the participants in terms of their socio-economical background. There was no participation from disabled people. The gender was limited to include only women. However, women itself is a multiple and a fluid identity as it could be seen from the participants' narratives (See Chapter 5).

The findings of this research are focused on the views, thoughts, and viewpoints of 29 women from four universities in Dublin. Thus, it can be considered as a local research that focuses on a specific Irish city. Dublin, on the other hand, is becoming a global community, and some of the research participants come from all over the world as can be seen from the participants list (see, Chapter 5). From this perspective, my study sampling can be considered as diverse. There were more similarities than differences among the participants' challenges, struggles, and the way they build their science identities in this research. The disparities are mostly based on their standpoints. Including universities from other cities in Ireland could have given me a different (or similar) picture, based on the research participants' personal experiences, viewpoints and how they situate themselves in science and gender context. The women who took part in this study do not represent all female scientists, researchers, or science students in Ireland. However, the participants' perspectives, opinions and experiences, which are bounded to physics and physical sciences fields in four Dublin universities, will still provide readers with insights into the women's science identity development.

In terms of ethnicity and religion, a few of the participants mentioned the influence of their ethnic and religious background on their science identification and sense of belonging to a scientific community. Participants from Western Europe and the United States did not discuss any discrimination based on their ethnic or racial backgrounds. Participants from Latin America, Asia, the Middle East, and Eastern Europe addressed how their various identities intersected and how this affected their sense of belonging to science. However, as I previously said, it has only provided me with a partial image of all science communities, both locally and globally.

With the inclusion of a broader representation of the diverse members of the physics and physical sciences department, further research might be conducted in the future with the analytic lens to reflect issues of sexuality, class, and ability. Additionally, a larger sample size with more variability among gender (identity) would definitely contribute to richer data.

Third, the sample population included participants from physics and physical sciences domains. Physical science is a broad discipline with encompasses physics, chemistry, earth sciences, astronomy along with subfields of these domains. In this research majority of the participants were undergraduate and graduate students from different subfields of physics. As opposed to undergraduate students, graduate students and early career researchers in this study had diverse academic backgrounds from different physical sciences domains. However, there was still very limited participation from other branches of physical science than physics. Further research in the future might include equal participation from each physical science domain to present more comprehensive data.

Fourth, I examined the participants' 'science identity' to provide unity among the them. However, I noticed that there are various constructions of 'science identity' depending on the disciplinary area of the participants. For example, as can be seen from the findings (See chapter 5), some of the physics students called themselves a 'physicist' rather than a 'scientist' by distinctively separating them. Some of them also sub-categorised 'physicist' identity by providing examples of 'energy physicist' from a 'medical physicist' from various constructions. One of the participants introduced herself as an 'astrophysicist' rather than a 'scientist'. This shows me the real diversity behind the label 'scientist'. Future studies can pay attention to these sub-fields by showing the differences and similarities across these identities.

Fifth, qualitative research is interpretative which is concerned with the deepening of understanding of a given situation through lived experiences, the perspectives and worldviews of the people involved as well as through social interaction, language, concepts, and discourses. As with my research, as I moved through the interviewing and analysis process, I thought about issues related to the limitations of this research. At first, I thought the questions I asked during the interviews, which were influenced by my research questions, represented my views, to a large degree. These questions were not independent of my subjectivity. Then, I evaluated where I was standing in this research process. Rather than ignoring my biases, subjectivity, worldview, and my background, I accepted them. My positionality met the positionality of the participants. I was influenced and formed my understanding of their experiences as well, and I remained reflective throughout. I am also aware that from the formulation of the research questions to discussing the narratives of the participants, this study is not as completely objective as any quantitative research would be. Rather than dealing with numerical and statistical data, this study centred on how people give meanings to their experiences, thoughts, values, attitudes, and finally interpreting them which cannot be reduced to collect information for (numerical) measurement.

Last, the terms both ‘woman’ and ‘female’ emerged many times in the study which might seem confusing and contradictory to the readers. The concept of ‘female’ which refers to a biological concept of womanhood contrasts with queer theoretical approach and gender performativity theory used in this research. The term ‘female’ was used as an adjectival form of ‘woman’ (like in female scientists) as it was widely used that way in the literature review. It also emerged from its use by bodies such as the HEA, as well as many others, for which I examined data on gender balance in science in the sense of Ireland. In certain cases (when it represented my thoughts), I preferred to use ‘woman’ as an adjective (like in woman scientist). As a non-native English-speaking woman, I preferred to use it as it is used in my native language.

## 4.13 Conclusion

Chapter 4 provides an extensive outline of the methodological approaches adopted in this research. A case study with an in-depth interview method was presented. It was followed by a description of the researcher’s background and position. The data generation techniques were explained, along with an overview of how data was analysed. Finally, after the challenges that the researcher experienced during narrative analysis interpretation and representation were explained, ethical considerations and methodological limitations were discussed.

# Chapter5 : Presentation of Case Study Data - Women's Narratives

## 5.1 Overview

This chapter collects and interprets the perceptions, views, and experiences of female students and early career researchers in the field of physics and physical sciences in higher education. The discussion focused on the impact of their gender on their science identity development, their challenges as female science students and researchers in academia, and the feminist movement's influence on their science identity development.

This chapter relies on discursive narrative analysis (see Chapter 4) of participants' interviews. The research questions that were addressed by this analysis were:

1. How do female students and early career researchers in physics and physical science fields in higher education construct their science identity related to their gender identity?
2. What are the challenges faced by them arising out of incompatibility between gender-science identity?
3. What is the role of the feminist movement on women's science identity development?

This chapter begins with a brief description of each participant. Then, a detailed analysis of the interviews is presented. The analysis is organized into three sections which directly addresses each of the research questions respectively.

## 5.2 Participants' profiles

The analysis presented here was carried out on data generated in individual interviews with 29 women from undergraduate to postdoctoral level enrolled in physics and/or physical sciences disciplines in four Dublin universities: Trinity College Dublin (TCD), Dublin City University (DCU), University College Dublin (UCD) and Technological University Dublin (TU Dublin). They were from the disciplinary subfields of theoretical physics, general physics, nanoscience, astrophysics, medical physics, material physics, physics with energy and environment, energy science, visual optics, physics and chemistry, space science, earth science, and physical chemistry.

All participants were over the age of 18 years with the youngest aged 18 years and the oldest aged 40 years. Out of 29 participants, 11 were undergraduate students, 12 were graduate students (2 master's and 10 Ph.D.) and 6 were postdoctoral researchers.

The interviews were conducted in the spring semester of 2019 from early March to June and most of them were held in an empty and quiet room booked for the interviews in the School of Education, TCD. One of them requested a Skype interview as she had to be at home to mind her children. Four of the participants preferred to meet either in their offices or a café in their institute, and two of them booked a room for the interview in their workplace.

To preserve the anonymity of the participants each of them is assigned a pseudonym chosen by the researcher before the analysis. The pseudonyms were selected using a website which provides a list of sound-alike names. However, the chosen pseudonyms are not obvious to avoid immediate identification.

The following table shows the list of the interview participants

Table 5. 1 Research interview participants

| Pseudonym | Institution | Level of Study | Degree of Study | Age | Country of origin |
|---|---|---|---|---|---|
| Ramya | TCD School of Physics /CRANN Institute | Postdoc | Material engineering/ Physics | 29 | India |
| Carol | TCD School of Physics | Postdoc | Astrophysics | N/A | Argentina |
| Dee | TCD School of Physics | Postdoc | Astrophysics | N/A | Ireland |
| Lou | TCD ICRAG Centre | Postdoc | Hydrogeologist, Geoscience /Earth science | 31 | France |
| Amada | TU FOCAS Institute | Postdoc | Medical Physics & Biophotonics | 40 | India |
| Mia | TCD School of Physics | Postdoc | Computational Spintronic | 38 | Bulgaria |
| Sophia | TCD School of Physics | Ph.D. -4th year | Material physics | 32 | Italy |
| Jill | TCD School of Chemistry-CRANN | Ph.D.- 3rd year | Physical / Computational chemistry | 27 | Brazil |
| Lara | TCD School of Physics | Ph.D. -2nd year | Astrophysics | 24 | Ireland |
| Aine | TCD School of Physics | Ph.D.- 3rd year | Solar physics / Astrophysics | 26 | Ireland |
| Kelly | TCD CRANN /AMBER Institute | Ph.D.- 3rd year | Nanoscience | 27 | Ireland |
| Julianne | TCD School of Physics | Ph.D.- 1st year | Astrophysics | 22 | Ireland |
| Kathryn | TCD School of Physics | Ph.D.- 1st year | Nanoscience /Physics with chemistry | 23 | Ireland |
| Neha | UCD School of Physics | Ph.D.- 4th year | Visual Optics | 29 | Bangladesh |
| Ale | UCD School of Physics | Ph.D.- 3rd year | Visual Optics | 27 | Spain |
| Samiya | UCD School of Physics | Ph.D.- 4th year | Visual Optics | 35 | Saudi Arabia |
| April | UCD School of Physics | MSc | Space science | 22 | Ireland |
| Shalini | TCD School of Physics | MSc | Energy Science | 22 | India |
| Diane | TCD School of Physics | BA – 3rd year | Physics and chemistry | 21 | Ireland |
| Chloe | TCD School of Physics | BA – 2nd year | Theoretical physics | 18 | Estonia (raised in Ireland) |
| Joan | TCD School of Physics | BA- 2nd year | Theoretical physics | 20 | Ireland |
| Roda | UCD School of Physics | BA- 2nd year | Physics | 20 | Ireland |
| Annie | TCD School of Physics | BA- 1st year | Theoretical physics | 18 | Spain |
| Molly | TCD School of Physics | BA- 4th year | Theoretical physics | 22 | USA |

| | | | | | |
|---|---|---|---|---|---|
| Reese | TCD School of Physics | BA – 3rd year | Physics | 21 | Pakistan (raised in Ireland) |
| Dora | DCU School of Physical Sciences | BA- 4th year | Physics with Biomedical Science | 22 | Pakistan (raised in Ireland) |
| Nicole | DCU School of Physical Sciences | BA – 3rd year | Physics with Astronomy | 21 | Ireland |
| Cuca | DCU School of Physical Sciences | BA – 3rd year | Physics with Biomedical Science | 21 | China (raised in Ireland) |
| Demi | TU School of Physics | BA- 4th year | Physics with Energy and Environment | 22 | Lithuania (raised in Ireland) |

## 5.3 Biographical talks- Becoming scientist – background experiences

This section gives some detailed information about each participant based on their educational history, their early interest in science, how they were attracted to science, and what particular areas they discussed on during our conversations. Before moving on to a deeper understanding of their experiences, self-evaluations, and perspectives, I think it's necessary to introduce the participants. This information, I believe, will help the readers make a connection between the participants' early interest in science and their subsequent interpretations of science and gender identity.

### 5.3.1 Early career researchers

*April 10th, TCD*

**Dee:** She is a postdoctoral fellow in astrophysics. She studied theoretical physics and switched to astrophysics for Ph.D. Dee associated her interest in physics with mathematics. She said she was very good at mathematics at school. She, on the other hand, did not consider which topic she would study until the very last minute. She chose theoretical physics to follow in her brother's footsteps. She claims that when she was younger, girls were motivated to pursue biology rather than physics. During our conversations, she primarily discussed family-life balance, maternity, child-care, and postdoctoral career instability.

*May 7$^{th}$, TCD*

**Lou:** Lou is one of the few women I interviewed who does not have a background in physics. At the time of our interview, she was a Geoscience postdoctoral fellow working in a research centre. Her parents and teacher encouraged her to pursue science because it is regarded as prestigious in France and can lead to more opportunities. She spent two years in a preparatory engineering school in France, where she studied mathematics and physics. She decided to specialize in earth science after two years. For a year, she worked as an engineer. She earned a Master's degree in hydrology after her contract ended, and then pursued a Ph.D. During the interview, Lou was very talkative and accessible, addressing her challenges as a woman scientist in academia

*March 28$^{th}$, TCD*

**Ramya:** Ramya received a BA in biotechnology and an MSc in energy engineering. She was working on filtration materials used for different kinds of separations as a postdoctoral researcher in the School of Physics when we met. She said that she fits into physics because all the basic principles she uses for work is about physics, but she has most of the engineering knowledge and skills as well. She is married. Her husband is also a postdoctoral fellow, which she claims simplifies things. After completing her master's degree, she became interested in pursuing a career in academia. Her Ph.D. supervisor, who had a science background, was an inspiration to her.

*May 29$^{th}$, Skype*

**Mia:** Mia was interested in my research and wanted to participate in the interview, but due to the fact that she had a baby when I was interviewing and had to care for her until the end of June 2019, she offered to interview me via Skype or meet in person in July**.** As I planned to finish the interviews by early June, we decided to talk on Skype. She is a mother of three children, and when we met, she had just returned from maternity leave.We also discussed maternity-related topics. She studied theoretical physics before moving on to nuclear physics.  She earned a master's degree in nuclear physics and a Ph.D. in materials science. Her interest in science grew after she joined in a physics after-school club and participated in a physics olympiad in high school. In her early years of education, she considered physics to be interesting and enjoyable.

*May 13th, TU Dublin*

**Amada:** Amada moved to Ireland for postdoctoral study after receiving a Ph.D. in medical physics in India. Her career in research was in the area of bio-photonics. She is a single mum with 15- year-old son. She primarily discussed family-work balance, maternity leave, and her challenges as a single mother. In comparison to her previous experiences, she now finds herself in a new situation. In comparison to her previous Ph.D. experience where she worked in an extremely man-dominated setting, she believes her research group is diverse at her current job.

*March 26th, TCD*

**Carol:** Carol was waiting for me in her office at the School of Physics when I arrived.  It was a friendly conversation over tea. Carolina earned her bachelor’s degree and Ph.D. in astronomy. She was motivated by her interest in space in primary school. One of her high school teachers arranged for her to do an internship at the observatory, where she met astronomers. She became very interested in astronomy and wanted to pursue it. She was one of the few women who completed their studies at university, but it wasn't until she began a postdoctoral career that she realised the issue of underrepresentation at conferences and on staff. She discussed socioeconomic and ethnic inequalities in science during our conversation. Carol reached out to Dee, who works in the same office as her.

### 5.3.2 Graduate students

*March 12th, TCD*

**Sophia:** At the time of the interview, Sophia was in her fourth year of Ph.D. studies. In the School of Physics, she was studying polymer chemistry. She has a Bachelor's and a Master's degree in chemistry. At college, she excelled in science and mathematics. She said that she knew she wanted to be a scientist the moment she walked into the lab to conduct an experiment. She was always intrigued by simple experiments, even at home, since she was a child. She has a strong feminist identity, and she spoke extensively about what feminism entails and has done in terms of gender equality in science

*March 21st, TCD*

**Jill:** When the interview took place, Jill was in her third year of a Ph.D. program in computational chemistry. She moved to Ireland to pursue her Ph.D. She chose chemistry because she knew that getting a job after math and physics would be difficult. Also, she was inspired by her chemistry teachers. She also found chemistry very interesting. She began working in a large company in Brazil after earning her bachelor's degree, which had little to do with her studies. She believed there was no point in pursuing a career she didn't really care about. She mainly addressed gender inequality at the senior level, as well as ethnic/racial stereotypes and their effect on people's need to prove themselves.

*March 20th, TCD*

**Lara:** Lara was a second-year Ph.D. student in astrophysics in the spring semester of 2019 when the interview took place. She is a physicist who is interested in the mathematical aspects of the subject. Her lifelong fascination with mathematics inspired her to pursue a career as a scientist in her teenage years, when she became more interested in space and physics. Physics, especially astrophysics, was the most enjoyable way she could think of to do mathematics. When she was a child, her father had a huge influence on her. She recalls her father buying her a lot of science books during those years. Lara describes herself as a nerd since she was around 7 or 8 years old. She attended an all-girls boarding school for a year before transferring to a mixed secondary school. She believed that physics was not a choice at the all-girls school because only a small number of girls were interested in the subject. Another issue is that there are insufficient physics teachers in Ireland to teach at the high school level. We had many fruitful discussions, ranging from her strong interest in mathematics and science to second-level science education in Ireland, from the feminist movement in science to gender issues, all based on her personal experiences. Lara was an executive committee member of WITS Ireland (Women in Technology and Science) at the time of our interview. Lara contacted me Carol who was a postdoctoral researcher in her department.

*March 25th, TCD*

**Aine:** Aine started her third year of Ph.D. in solar physics when we met in the spring semester of 2019. Her bachelor's degree is in astrophysics. She earned a master's degree in space science and technology. She worked as an intern for the European Space Agency (ESA). Her interest with space began in primary school, when she and her classmates worked on a project about heroes in their lives. One of the boys in the class did a project about Galileo that stayed with her and ignited her interest in science and space. She knew she needed physics in high school to do space, but she admitted she wasn't interested. Art, drama, and biology were among her other passions. She participated in an outreach program in Trinity during her transition year in high school, which she did physics for one week. She adored it, not only because of the subject, but also because of the school's atmosphere. She characterized herself as a stubborn and inquisitive person which, for her, is important to continue physics. During the interview, Aine was very open to sharing her thoughts and gave lengthy, thorough responses to my questions.

*March 27$^{th}$, TCD*

**Kelly:** Kelly holds a bachelor’s degree in nanoscience. She was a third-year Ph.D. student in physics. Kelly went to a mixed primary school and all-girls secondary school. Both her mother and father came from a ‘mathsy’ background. She credits them as a source of inspiration for loving mathematics in her early years at school. She started doing a young scientist competition in secondary school and chose physics and applied mathematics as optional classes. In high school, she entered a young scientist competition and selected physics and applied mathematics as optional courses. She believed that solving problems gave her more joy than any social science course. Kelly pursued her passion by combining physics and chemistry in her studies. She also enjoys photography and dancing, which she believes distinguishes her from other female physicists who she considers nerdy.

*March 26$^{th}$, TCD*

**Julianne:** At the time of our interview Julianne had recently begun her Ph.D. in nanophotonic. She completed her bachelor’s degree in physics and astrophysics. She changed her focus to nanophotonic for Ph.D. as she likes to do more experiments in the laboratory. She associates her interest in physics with mathematics. Applied mathematics and chemistry were her favourite subjects at school. She wanted to be a writer in her early years, but she was better at mathematics. Her mother studied mathematics and her grandmother did chemistry in college. Julianne was a little nervous at first, offering brief answers to my questions, but after a while, we were relaxed with each other and had an easy and friendly conversation.

*March 19th, TCD*

**Kathryn:** Kathryn received her bachelor's degree in nanoscience. Her supervisor asked who might be interested in her project, which was both chemistry and physics based, in a lecture during her final year of undergraduate studies. Kathryn became involved in it and obtained a Ph.D. after completing her undergraduate degree. She is interested in material science. In secondary school, she loved all science subjects, especially physics, chemistry, and applied mathematics. She was always fascinated by how things worked, even as a child. Her secondary school physics teachers were also very inspirational, which she considers to be advantageous. She considered herself fortunate during her school years because her school offered applied mathematics and physics classes, whereas most other schools did not. During the interview, she was very chatty. We spoke a lot about queer, gender performance, and sexuality in addition to science.

*April 12th, UCD*

**Neha:** Neha was a final year Ph.D. student in visual optics at the time of the interview. She earned a bachelor's degree in physics and a master's degree in photonics. She claimed that after completing her Ph.D., she will either work in industry or academia. When we met, she was under a lot of stress due to her studies. She said that there was a lot of pressure on her. The idea of becoming a scientist started in her early years. She got inspired by reading stories about scientists, discoveries, and experiments. Her parents encouraged her to pursue a career as a scientist. Her father, she said, was a major supporter of her choices. She was particularly fond of optics at university because one of her professors taught it in an engaging manner. She talked at length about gender roles, ethnic identity, and struggles of a Ph.D. She was happy to volunteer for my Ph.D. project. When I said I would need more participants from UCD, Neha provided me with contacts to two Ph.D. students in optics.

*May 16th, UCD*

**Ale:** I met Ale after Neha gave my contact details to her. I set up an interview date one month later as she was away until mid-May. Ale told me that she liked technology and got into industrial engineering first. Then she realised that she was much more interested in optics and she was told that she would not do it through engineering. So, she shifted to physics and completed her undergraduate degree in physics. From an early age at school, she had always been interested in mathematics and science. “You have to be very determined about what you want to do,” she said. When she told her friends and teachers that she wanted to study physics, they were all taken aback because all of her peers were encouraged to pursue careers in medicine, engineering, or biology. During the interview, it became obvious to me that she is a very committed person, just as she described me as a scientist. Through her own experiences, she frankly shared her thoughts on becoming a woman in physics.

*May 16th, UCD*

**Samiya:** I met Samiya on the same day I interviewed with Ale. They worked together in the same office.

Samiya earned her bachelor's degree in physics. She moved to Ireland to obtain her Master's degree in NanoBio Science. She was in her final year of Ph.D. studies at the time of the interview, working in an advanced optical imaging group with Ale and Neha. She was good at all science subjects especially physics in high school. Her parents and teacher tried to encourage her to study medicine, but she was so excited about physics that she wanted to try it. She attended a women's college, so she was unaware of the gender disparity in physics at the university level at the time. It took her three years to persuade her parents to pursue further science studies in another country, she said. She is enthusiastic about her work and enjoys doing research

*April 1st, TCD*

**April:** When we met, April was enrolled in an Astrophysics master's program. She received a science bachelor's degree. In her transition year of high school, she became interested in astronomy and physics. She completed a three-week physics and astronomy module. She described it as unusual since these subjects were not covered in school. She was advised to study social sciences and teaching when she went to the career guidance counsellor in high school. Instead, she chose to pursue a degree in science at university. She plans to obtain a Ph.D. in astrophysics. She mentioned that three weeks prior to our interview, she enrolled in an outreach program and visited her former high school. The students could not believe she was a physics student from the same school. She claimed that it seemed to them to be unattainable. April was very polite and comfortable during the interview, which allowed for a smooth and casual conversation.

*March 28th, TCD*

**Shalini:** Along with Rachel, Shalini was the only master's student I interviewed. At the time of the interview, she was studying a degree in Energy Science. In her class, she was the only female student. She graduated with a bachelor's degree in electronic and electrical engineering. Her father is an engineer, and her mother is a stay-at-home mother who has recently taken over her father's business. She described her mother as a housewife businesswoman. She was very good at science, especially physics and biology from her early years at school. Shalini had no desire to pursue a career in academia. When I asked about her future plans, she said that she would either pursue an energy law course or a business degree before starting a career in the industry. She described herself as a successful, career-oriented woman who is also passionate about science.

### 5.3.3 Undergraduate students

*March 23rd, TCD*

**Diane:** At the time of our interview Diane was enrolled in the third year of the undergraduate programme in nanoscience. Inspired by her grandmother she wanted to be an English teacher when she was in primary school. In secondary school, she joined a mathematics enrichment programme run by the mathematics Olympiads. She was invited to mathematics classes on Saturdays and got interested in mathematics. She went to two different high schools. First, she went to a mixed secondary school which had lots of disciplinary problems. So, the teachers were just focusing on getting everyone to class and to be quiet. Then she moved to another secondary school for her final two years where she met very engaging mathematics and chemistry teachers who encouraged her to continue with science. She is active in the feminist science movement. She attempted to form a society with her peers, but it was rejected because her university had already covered women in STEM. We had a robust conversation on a variety of topics, ranging from self-confidence to female role models in science, from gender identity to diversity issues in science.

*March 22nd, TCD*

**Chloe:** Chloe is one of the youngest of all the participants along with Annie. She was eighteen years old at the time of the interview, studying theoretical physics at TCD. She described her father as being interested in science. As she said, if she was to pick up someone as a role model, it would be her father. He used to provide her with lots of books about science. Her interest in physics came primarily from her interest in science fiction. She was very much into space, dinosaurs, robots, and science fiction books when she was a child. Her dad got a book from one of his students which were about the universe. It was inspirational for her. Chloe wants to go into academia just like her dad who was once in academia. She described science as a road to discovery and she wants to do the best that she can.

*April 2nd, TCD*

**Joan:** Joan was enrolled in the second year of an undergraduate program in TCD when the interview took place. She was studying theoretical physics. She has always been good at mathematics and science. Even in primary school, she was finishing mathematics questions early. In secondary school, she used to do well on mathematics tests. When his brother who was two years older than her was recommended by his teacher to do science in the Centre for Talented Youth Ireland, she wanted to do it as well. She was inspired by her brother's success and went for it. In secondary school, during the transitional year, she joined an early university entrance programme run by DCU. She chose the mathematics module there. She said that that was probably when she kind of knew that she wanted to do mathematics and physics in college. She decided to do theoretical physics in TCD when she learned that she could swap mathematics at any stage if she wants.

*March 29th, TCD*

**Roda:** Roda was in her second year of physics with an astronomy and space science undergraduate program when I met her. She took biology, chemistry, physics, and applied mathematics in her first year.

She began studying physics in her second year. She did not realize she wanted to study physics until she started. She wants to pursue a career in academia because she enjoys learning. She is a founding member of her university's Women in STEM organization. She has also been involved in a lot of outreach work, holding workshops in primary and secondary schools, particularly in rural communities. She stated that science had always sparked her interest. When she was younger, she enjoyed watching science documentaries. Even in primary school, she loved doing simple scientific experiments. In secondary school, she went to an all-girls school.  She considered herself lucky in terms of having brilliant science teachers. Her physics teacher particularly was very encouraging. She said that while most all-girls- secondary school do not offer physics at the second level due to lack of staff or a little number of students who want to take physics class she was lucky to choose it. She mentioned that if you come to college to study science and physics but have never done so before, even in your high school diploma, you will be afraid because it is similar to learning a new language. One of the reasons why girls have anxiety about physics, according to her, is because of this.

*March 7th, TCD*

**Annie:** Annie was the first participant I interviewed. Annie had just started an undergraduate program in theoretical physics at the time of the interview. She has always loved science since primary school. She was particularly good at mathematics. As she did not live in a big city, she did not know the career opportunities focused on pure physics. Her parents were initially hesitant to encourage her to pursue a career as a physicist, fearing that she would be unable to find work in the future. Her teachers encouraged her to pursue medicine as a college major. She claimed that it was in high school that she realised that girls who succeeded in science would pursue careers in medicine and related fields. She has known since the beginning of the course that studying theoretical physics was the right decision.

*March 26th, TCD*

**Molly:** Molly moved to Ireland to study physics. She was in her final year of an undergraduate programme in physics. Molly was very enthusiastic to talk about her experiences as a college student and her passion for science. She has been interested particularly in space since she was very young. She wanted to be an astronaut when she was a child. Her mother studied biochemistry and her dad did a mathematics major in college. They encouraged her interest in science from her early years. She was pretty good at mathematics in high school. She claimed that she was surrounded by people who were passionate about science, which encouraged her to pursue a career in the field.

*March 8th, TCD*

**Reese:** I met Reese through her mother, with whom I worked at the DCU Educational Research Centre for PISA Scoring. Reese was the first person I contacted, even before I began formally recruiting participants. When the interview took place, she was in her third year of a theoretical physics undergraduate program. She was nine years old when they moved to Ireland. Her mother was doing a Ph.D. in DCU when I met her. Reese was well-educated and sophisticated. She went to an all-girls school in Dublin. She said for the last two years of the school she along with her friends had classes with the boys because the girls-school did not have their own physics teacher. She said that the schools did not provide teachers as few girls were interested. Her passion for physics came from her interest in mathematics. In her transitional year of secondary school, she took applied mathematics which got her thinking about physics.

*March 15th, TCD*

**Dora:** Dora was a final year undergraduate student in physics with biomedical sciences at the time of the interview. During the interview, she was very talkative and confident. She was extremely enthusiastic about physics. Dora strongly identified herself as a physicist, not a scientist. She said she had always been interested in watching physics documentaries since she was younger. Her parents are both doctors who work long hours. She spent a lot of her childhood alone at home watching science documentaries. She was particularly fascinated by how the world worked. She was interested in all science subjects, but she decided to pursue a degree in physics because it met all of her requirements.

*March 16th, TCD*

**Nicole:** Nicole was an undergraduate student in physics with astronomy undergraduate programme when the interview took place. She was in her third year and on a job placement until September 2019. While watching space documentaries with her parents as a child, she developed an interest in science, especially in space. Her parents, she said, were big fans of science fiction and documentaries, and that was what drew her in. Her parents were not college graduates, but they encouraged her to pursue a college education. Her mother, on the other hand, was against her choosing physics because she wanted her to study the arts. Her mother, she said, had an artistic background and taught her various art techniques. Nicole stated that she enjoyed art as a hobby, but that she could see physics as a career.

*March 9th, TCD*

**Cuca:** Cuca was studying physics with biomedical sciences at the time of the interview. She was in her third year and was on internship. She got interested in science from the junior certification. Her mother is a chemist, which for her influenced her to study physics. She said she did not follow her steps to study chemistry because she was more interested in physics. She said physics was the right fit for her. Cuca was not among the talkative participants. She seemed comfortable during the interview, but she gave relatively short answers compared to other participants.

*April 29th, TU Dublin*

**Demi:** Demi was enrolled in an undergraduate program in physics with an emphasis on energy and the environment when the interview took place. She majored in industrial and environmental physics for the first three years of her education. When we met, she had just begun her level eight study of physics with energy**.** Demi has a different story than the rest of the participants. She did not study science at secondary school. She moved to Ireland with her parents when she was ten years old. She chose music, art, geography, and history in secondary school. It was a new country for her. It had already been three years since she was in Ireland. She said she was confused about which particular courses she was interested in. For the leaving certification, she was not allowed to choose science courses as she had never done science before. She wanted to choose art. She described herself as an artistic person. Her parents disagreed with her studying art. On her CAO (The central application office) application, she mostly chose social sciences courses and only one physics course that she could find in DIT which is now TU Dublin. She wanted to apply for industrial and environmental physics because she was interested in renewable energy and felt it would be a good fit for her future career. Demi stated that it was difficult at first because everyone in her class did science except her. But as she worked through it, she discovered that physics was a fascinating subject. She claimed that she discovered how fascinating physics was by accident and fell in love with it during her undergraduate studies.

## 5.4 Analysis of the Women's Narratives

Women's narratives presented in this section are based on individual in-depth interviews with the research participants. The interviews were analysed using a discursive narrative analysis, as described in the methodology chapter (see, Chapter 4).

In this chapter, the women's narratives are broken down into three sections, each of which corresponds to one of the three research questions.

Section I addressed the research question I: "How do female students and early career researchers in physics and physical science fields in higher education construct their science identity related to their gender identity?" Six main themes as well as eleven sub-themes were presented in this section.

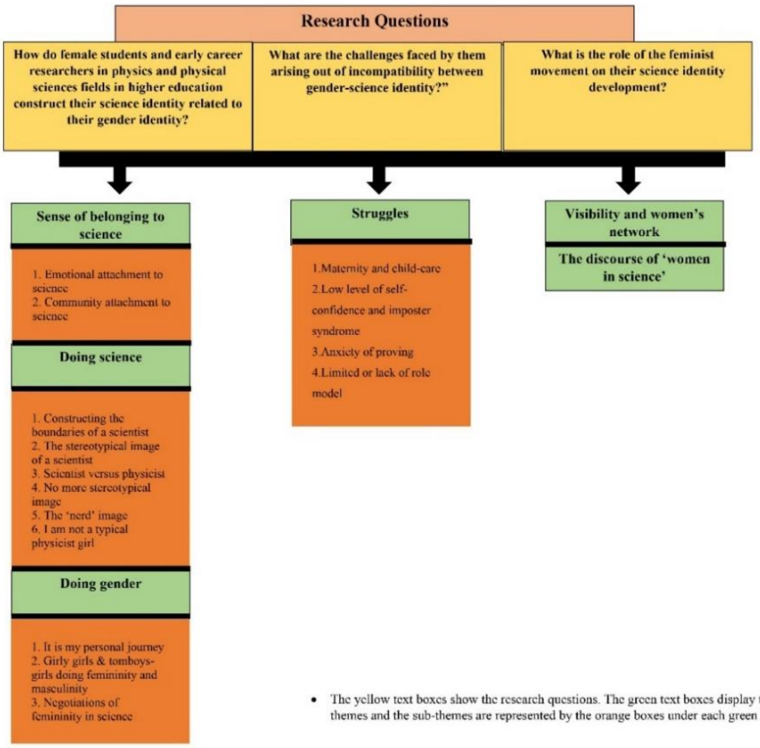
Section II aimed to find an answer to the research question II: "What are the challenges faced by them arising out of incompatibility between gender-science identity?" This section includes one main theme and four sub-themes.

Section III sought an answer to the research question III: "What is the role of the feminist movement on women's science identity development?" The focus of this section is on two main themes.

After in-depth analysis and presentation of women's narratives according to the themes and the subthemes of each section in this chapter, the next chapter (see, Chapter 6) focuses on the discussion of each research questions in the light of the literature review and the theoretical context of the study. Chapter 6 is based on three research questions and the main themes that relate to each of the research questions.

The following chart illustrates the presentation of the themes and subthemes that support the research questions in this chapter. The following sections analyse and present the themes and subthemes in greater depth, along with quotes from the participants.

Figure 1 Framework of research questions, themes and subthemes




- The yellow text boxes show the research questions. The green text boxes display the main themes and the sub-themes are represented by the orange boxes under each green box.

### 5.4.1 Section I: Research Question I

The research question that was addressed the analysis and presentation of findings in this section was:

***How do female students and early career researchers in physics and physical science fields in higher education construct their science identity related to their gender identity?***

Three main themes and eleven subthemes that arose from the coding and analysis described in Chapter 4 are presented in this section. Under these three main topics, the participants' sense of belonging to science (within their particular disciplines), both individually and collectively, as well as how they perform science and gender, were examine. The themes are consistent with how science and gender identity is conceptualized in this research.

As discussed more in detail in the literature review (see Chapter 2), science identity is conceptualized in the framework of sense of belonging and performance, and gender identity is based on women's self-identification and performativity. Thus, the main themes '*sense of belonging to science, doing gender,* and *doing science'* are formed according to how 'science' and 'gender' identities are conceptualized in this study. Then, the subthemes were identified under each main theme.

Overall, the data show how they construct their science identities in relation to their gender, with a focus on self-evaluation, self-identification, and lived experiences.

A physicist and a scientist were separated by some of the participants. Finding a woman with a physics background, especially at the post-doctoral level, was extremely rare in Dublin, where my research took place. Some of them studied chemistry before specializing in physics, while others earned a bachelor's degree in engineering before switching careers to physics. All of them have a heavily 'mathsy' background and the majority work in physics departments and research institutes, but some have degrees in chemistry, earth science, or engineering and are working on physics-related projects. Thus, I have investigated their academic and professional identities under the umbrella term of 'scientist'.

## Theme I - Sense of belonging to science

This theme was developed to analyse the role of a 'sense of belonging' on women's science identity development. The analysis of the data revealed two subthemes: (1) emotional attachment to science, (2) community attachment to science. The subthemes were shaped by the analysis of the discussion data in terms of what attracted them to their discipline and how they feel about it. They mostly talked about how they developed an individual attachment to science and how they feel in a scientific community around them.

### *Emotional attachment to science*

*Science is not just what I do. It is exactly who I am*
*Sophia, PhD*

I expected this theme to emerge during the interviews. After many years of working as a secondary school teacher, I have learned from the students that if they are interested in what they are doing, they are more likely to progress and complete the necessary task even though it is difficult. They have a hard time engaging with what they do if they are uninterested. So, prior to the interviews, I assumed that the women I would be interviewing would be interested in science. Of course, there are other factors that influence one's science identity and persistence, but I've observed that the presence of interest influences young people's growth of relevant identity in a positive way.

The participants in this study are over the age of eighteen. I briefly described their early interest and first involvement in science in their school years or childhood in the previous section, where I gave some biographical information about the participants. With this theme, I wanted to dig a little deeper and see how important it is to develop an emotional attachment to science in order to develop a strong science identity.

The following were the most common phrases found in the data:: ‘I enjoy science’, ‘It is cool’, ‘I love it’, ‘It is part of me’, ‘It is my interest’, ‘I enjoy doing it’, ‘It is interesting’. All of the participants expressed an interest in science, particularly mathematics and physics.

The majority of them stated that they have always been good at mathematics or that they love mathematics so much that they chose physics or physical sciences as a career. One of the participants said: “*Science is exactly like language. You need to know different perspectives of it. Or you need someone or something that gives you a certain vocabulary. Well, mathematics, for example, gives you the vocabulary, it explains to you how science works.* (Sophia, Ph.D.).

Julianne (Ph.D.) explained how she became interested in science:

> *Julianne: Because I just liked mathematics.*
> *Me: Why specifically physics?*
> *Julianne: First, I went into general science and I was not sure if I would specialize in physics or chemistry. Physics kind of got more interesting as it got to a deeper level.*

In the interview excerpt above, Julianne’s phases ‘I just liked mathematics’ and ‘physics kind of got more interesting’ shows that she associated mathematics with science. Her interest in mathematics was her first step into science. Then, she found physics more interesting as she got more involved in it.

Kelly (Ph.D.) talked about the pleasure she derived from solving problems which she linked with mathematics. She stressed the importance of mathematical skill (solving problems) to get involved in physics. Her interest in mathematics that involves solving problems and getting answers is closely associated with her developing emotional attachment to physics.

> *Me: So why did you specifically choose physics?*
> *Kelly: I really liked Mathematics. I like solving problems, you got such satisfaction from a more definitive satisfaction than you would in any other*

*subjects. Cause it is like I got the answer. I know I got the answer. That is quite nice, I thought.*

Kelly told me that she thought about studying medicine as people suggested her to go for medicine, but she followed her interest and chose physics.

*Kelly: I did think about it, doing medicine, and loads of people were like, Oh, you are smart enough to get certain points for medicine, but I just didn't have as much interest in that.*
*Me: So, you just followed your interest?*
*Kelly: Yeah, I definitely followed my interest. I was lucky that I was able to follow my interests.*

Joan (BA) also associated physics with mathematics. She repeatedly stated during the interview that she loved mathematics so much that she ended up studying physics. At the time of the interview, Joan's brother was also doing physics at a Ph.D. level at the same university, I did not ask her why she chose physics over mathematics if she loved mathematics that much, but I guess she followed her brother's step.

*I am interested because I prefer mathematics. I decided to do theoretical physics mostly because I have found out that if you do theoretical physics here in Trinity, you can swap mathematics at any stage. So, like at any stage, I can decide to move to mathematics. I love it.*

Joan's interest in mathematics prompted her to study physics. Besides, Joan told me that before starting college, she participated in a DCU outreach program. She went to DCU once a week to study first-year college-level modules. She expressed: "I decided to do mathematics module and I found that really interesting. So that is probably when I kind of knew I wanted to do mathematics and physics." Joan's interest in mathematics and physics, like that of the other participants, is critical to the development of her scientific identity.

Dee (postdoc) said she got into physics because she was good at mathematics, just like Joan. She became interested in physics as a result of her mathematical abilities.

> *Physics is just very strongly linked with maths. People said I should do physics because I was good at maths. At the end of the day, I am very happy with what I have been able to do.*

Dee's scientific identity is formed by her involvement with mathematics. Her mathematical ability has bolstered her sense of competence, causing her to be satisfied and develop a positive attitude toward physics. When Dee believes she is good at something and can achieve it, she engages in it and develops a sense of belonging to it, as evidenced by her phrase "I am very pleased with what I have been able to do."  As a result of her interest and aptitude in mathematics, she chose physics as a college major and later specialized in physics at the postdoctoral level.

Just like Dee, Reese (BA) also associates herself with the mathematical aspects of physics which emerged as a central idea under this subtheme. She commented:

> *I just always liked maths. That was my particular interest. When I was younger everybody told me, I was good at maths. I really enjoyed maths. I want to stay in physics for a little bit longer. So, then maybe I can specialize in something like fluid dynamics, which is very 'mathsy' heavy, very 'physicsy'.*

Reese talks about her interest in mathematics which eventually led her to choose physics at college. She is so enthusiastic about mathematics that she has expressed an interest in specializing in something that is both 'mathsy' and 'physicsy.' It is also worth noting how she described her interest in mathematics as a pleasure in the interview excerpt above. She enjoys math so much that she wants to pursue a career in the 'mathsy' and 'physicsy' fields.

Lara's (Ph.D.) reason for progressing in physics is also her interest in mathematics. Just like Kelly, Lara also stated that she was first suggested by her friends, family, and teachers to study medicine at college when she did quite well in the leaving certification. She said she did not want to be a doctor. She loved mathematics so much that she wanted to study something related to mathematics. At that time the career guidance suggested she do something along the lines of chemical engineering or actuarial science which are both mathematical. She explained why she chose physics as such:

> *I loved applied maths and I was getting more into the physics subject. Physics just seemed really cool and. It just seemed the most interesting and most fun way to do maths that I could think of. And the reason I chose physics, it is science and it's the most "mathsy" science. There is more maths in it than there is chemistry or biology.*

Her statement below about why she picked physics and is continuing with it impressed me greatly. She had a powerful way of expressing her opinions about physics. It seemed strong to me because I could see my emotions reflected in my own academic disciplinary area. She commented:

> *If I didn't love Math so much, I have never would have ended up in physics.*

Lara's motivation to choose and progress in physics can be seen in the sentence above. Her statement exemplifies the importance of someone valuing something in order to have it despite difficulties. The statement of hers below explains that it is challenging to break the expectations when your interests and abilities are different from what society expects. She expressed:

> *From such an early age people are basing their interests on what society expects your interests to be. No one wants to do the subject they love if they feel like they are going to be like an outsider.*

Especially during the early teenage years, young people may be influenced by their peers to develop an interest in a specific course or to fulfil the perception of what girls and boys should be interested in. Aine who was doing a Ph.D. in Astrophysics went to an all-girls school. She emphasized peer influence over one's decision to choose a specific course.

> *If all your friends are doing biology, you are probably going to do biology. You know, you at the age of fifteen, you are not really gonna make a life decision on whether you want to be an astrophysicist or a biologist. You are just going to go where all your friends are going. In high school, I think there were four classes of biology and then four people in the physics class.*

Sophia (Ph.D.) stated that her interest and competence in mathematics inspired her to design her degree at college. However, it was when she first entered the laboratory that she wished to be a scientist. Sophia commented:

> *I always loved mathematics and science. Also, it was easier for me to study mathematics and science. I was very good. I was very good with minimal effort. But when I actually stepped inside the laboratory to make an experiment, then I realised that I wanted to be a scientist.*

Sophia's comment suggests that something you love and are good at the shape of your future aspiration. Sophia stated that while she had a general interest in science, she became more interested once she entered a laboratory. I noted during the interview that she was more interested in the experimental side of science.

Annie (BA) and Ale (Ph.D.) commented that their decision to study physics stemmed from high interest and competence in mathematics and science. They often say things like, "I have always loved maths" and "I was good at it."

> *I have always liked science since primary school, and I was quite good at it, I really liked maths. (Annie)*
> *I have always liked math and science. I was good at it as well in school. (Ale)*

The participants gave me the impression that they were both passionate about and competent in science. An eighteen-year-old participant who was studying theoretical physics at the time of the interviews summed it up. She said:

> *I want to do the best that I can, and I want to do what I want. (Chloe, BA)*

She went on to explain her passion for the things that make her who she is. Her emotional attachment to science, particularly to her field 'physics', constitutes not only her science identity but also who she 'is'.

> *I have always been interested in this field. If I were to find myself, I would be a scientist and also a complete nerd geek. That is what I defined this up. (Chloe)*

Similarly, Ale (Ph.D.) said that science is ‘part of who she is’. In the following excerpt, she described science as a certain way of thought and ‘approach to life’. She emphasized that she enjoys science so much that it affects her daily conversations. She commented:

> *I catch myself talking about science more than I would like to, I really enjoy it. So yeah, I definitely would say it is part of who I am. I think part of the way I believe things should work. It is a scientific approach to life.*

Carol (postdoc) felt a similar sense of belonging to science. Carol, like Ale, referred to it as a way of life. She stressed how much she enjoys science and how it affects almost every aspect of her life.

> *I love what I am doing. I feel that it is a part of my life. It is a way of life for me.*

Both Ale and Carol described science as ‘way of life’ and ‘approach to life’ which means they have embraced scientific thinking in all walks of their life, and they are so much involved in science in their daily life.

The narrative of physics and science as ‘interesting’, ‘cool’, ‘fascinating’, ‘unbelievable’ was reported by these young women as a kind of motivation to keep them in science.

> *The reason why I am studying physics is that I just think it is like, you know it is like absolutely unbelievable. It is so cool. It never gets boring, which is nice. (Roda, BA)*
>
> *When I was in college, I realised that physics was very interesting, you know, and it was pure accident that I got here and then as the years went on, I fell in love with physics more and more. (Demi, BA)*
>
> *It is something I am proud of. It is something I am passionate about. Since I was a child, I was very interested in how things worked. I really really liked physics. I thought it was really cool and very interesting. (Kathryn, Ph.D.)*

The phrases they have used are very strong to describe their enthusiasm in science. Roda's statement that "it never gets boring" demonstrates how much she enjoys physics. Demi’s phrase ‘I fell in love with physics’ and Kathryn’s words ‘it is something I am proud of’ shows that they are powerfully attracted to physics. These are strong words to describe one’s sense of emotion toward science.

Demi (BA) was the only participant who did not take any science courses in secondary school. She first met physics at college and she absolutely loved it. When we met for the interview, she was a part of a research community as an undergraduate student. She was very much proud of her involvement and ability in physics. Her statement “I fell in love with physics more and more” was much evident from the way she talks about the practical aspect of doing physics. She was very passionate about what she was going to achieve in the future. She stated:

> *If you just continue and you remind yourself, Oh, yeah, I am doing this because I love this. I love discovery and I love science. And going onto NASA, reading all their articles is so fascinating and interesting. So, that one hour of a boring lecture, it means nothing in comparison to what I wanted to achieve. And that is why I stayed. I have a goal and I just keep going for it.*

Demi’s persistence in science is based on her strong enthusiasm for science as well as the satisfaction she gets from doing physics. Dora (BA) similarly expressed that she was reinforced by the achievement and satisfaction she gets from doing physics to stay in that field. She commented:

> *It is a very big personal journey. I was always going to drop out of physics and first year because of how everyone made me feel about myself. But the only reason I stayed was that I was getting good grades and I was like, this is something I enjoy. I feel satisfied, you know, that was the only reason I stayed.*

Dora distinguished out from the other participants because she relished the opportunity to break the physics taboo that "not many people, particularly not many girls, do physicsy things." When I asked why she particularly chose to study physics at college, she responded:

> *It was challenging, and I really liked that it was challenging and that in a way I kind of enjoy the taboo that was around it, not many people did*

> *physics, and then even more so not many girls did physics. And I think, you know, I kind of enjoyed that.*

Molly (BA) was also among the ones who talked very passionate about science, especially physics. At the time of the interview, she was a final-year undergraduate student studying general physics. She impressed me as being extroverted and passionate. Her personality reflected in the way she spoke about physics and science.. She said:

> *I would have always had an interest in science. From the first year of physics, I just absolutely loved it. You have to really love what you are doing in order to succeed. You have to be passionate. You have to have curiosity. I get really excited about what I am doing.*
>
> *I think the biggest thing that I bring to my study of physics is just my enthusiasm, my passion for it. I really work hard, and I like as frustrated as I can get, I know that in the end, something is going to be a really cool thing that is going to come out of it.*

Molly, like Dora and Demi, emphasizes the satisfaction of accomplishment at the end of physics. Their constitution of science identity is reinforced simultaneously by their strong emotional attachment to physics and science and the feeling of accomplishment. Their phrases “you have to really love it in order to succeed” and “at the end, something is going to be really cool” illustrates that success and what comes out of doing science, in the end, keeps them motivated and encouraged in science.

What one of the postdocs said during the interview made me think about the importance of self-motivation in one's career advancement.

> *As a scientist self-motivation is very important. Those who have self-motivation regardless of whatever circumstance they work, keep going in science (Ramya, postdoc)*

I believe that self-motivation can come from a variety of sources. My participants' self-motivation stems primarily from their sense of belonging to science, as I have observed. I noticed Neha was tired when I met her, who was a final year Ph.D. student in optics at the time of the interview. She insisted that the Ph.D. was struggling and consuming all of her time, making her feel exhausted. When I asked her about what motivated her to keep going, she responded:

> *I love it. Otherwise, I wouldn't survive that long. Being a scientist is like my passion.*

Neha's strong sense of belonging is rooted in her passion to be a scientist. Her statement "Otherwise, I would not survive that long" illustrates that her emotional attachment to science, in other words, her love of science prevails the struggles that she has experienced so far.

Similarly, Samiya, who was in the same research group as Neha, claimed that she loved science so much that she did nıt mind putting in the extra effort.

> *Samiya: Introducing myself as a scientist for me… I am just following my interest and it is not for that, you know, the public image. I need to enjoy it at the end of the day. But I usually stay until very late in the office or the lab.*
> *Me: Isn't it hard?*
> *Samiya: It is hard, but I am enjoying what I am doing.*

The narrative above exemplifies a strong emphasis on the 'fun' side of science. Just like the other participants, Cuca's (BA) involvement in physics is linked with her description of it as 'interesting' and 'cool'. She stated that she had already decided to study science in college because she found science to be really interesting and cool. She became more interested in physics than in any other scientific discipline and pursued it. She commented:

> *Cuca: Well, I was very interested in science from the junior cert. It was really interesting to me. It is like this is cool. I was always going to do with a science degree, but I did not know which one.*
> *Me: Why specifically physics?*
> *Cuca: It just, it seemed like the right fit*

Cuca told me during the interview that she enjoys the experimental side of physics. An experiment conducted in secondary school sparked her interest. She described it as 'fun'. She shared her love of science and the joy she gets in doing experiments to define physics as a 'right fit' for her.

Likewise, Mia (postdoc) identified physics as part of her personality saying, “physics was my thing”. She expressed:

> *I had always thought that physics was my thing and it made me feel special.*

Mia told me during our interview that whenever she was down, she remembered the medals she had won in science competitions. Her statement ‘it made me feel special’ illustrates that she got satisfaction from her achievements in physics which, I think, made her feel special and developed an emotional attachment to physics.

***Community attachment to science***

*We are a huge community of women in science and we are doing a lot of good work*
*Aine, PhD*

During the interview, I aimed to learn about participants’ sense of belonging to a scientific community, because participation in science also means participating in the culture of science which is constituted by the members of the scientific community. As well as individuals’ understanding of self, identity also develops in relation to and through interaction with others (Kim et.al, 2018). Thus, understanding the science identity development of women requires looking at it from a community perspective as well.

The scientific community is a broad term that can be made up of scientists in academia, in academic conferences or industry (if they do an internship), of small working groups in the context of a classroom. It can also be a small group of friends who enjoy and participate in science, or someone who is a member of a specific discipline as a whole. My focus was on if they are valued and accepted by other members of the scientific community if they feel that they fit in, belong to, or a member of these science groups, how comfortable they feel, and how they all affect their science identity development.

The participants addressed the attitudes and practices that affect their perception of belonging to a scientific community, as well as their being and becoming a scientist, within their own disciplinary communities. The majority of the participants described science as a team effort. Their feelings of membership and acceptance in the scientific groups affect how comfortable they feel in the science domain and consequently build dedication and commitment to the science community.

Diane (BA) stated, “it is important that you can work well and be respected in your team”. She described the teamwork aspect of science as such:

> *You have to communicate your ideas as well and you can go and meet new people and share your ideas with them.*

For Diane, involvement in the science community includes building a relationship with other people doing science, having good communication with them, sharing your ideas, and building network. She was a class representative which, she thinks, allowed her to be more integrated into science groups around her. She commented:

> *I think if I was not a class representative, I would maybe be a little bit less integrated cause I would not have had those conversations with the different professors and to some extent, it is up to you whether you decide to sit in class quietly or go to the events or talk to people and get involved. I think that is true for both boys and girls, but maybe it is more important for the girls to be a little bit active in networking, building their network, building their sense of community.*

Building a sense of community within a department, according to Diane, requires active involvement and engagement with people who do science both within and outside of the school setting. In order to create networking, Diane distinguished between boys and girls in terms of their participation in the scientific community. I also got the impression from the participants' narratives during the interviews that they want to see more women doing science around them and being more involved in scientific communities, research groups, and classrooms.  Diane's mention of gender has grabbed my attention in this narrative. “It is more important for the girls to be a little bit active,” she says, implying that she valued women's active participation in science and integration into their disciplinary communities.. She backed up this saying “that could start to change the perception of what a scientist is." For Diane, the more women are active in scientific communities and share their ideas with people, the better people can picture what and who a scientist is.

Like Diane, Demi also had an active role in the scientific community at her college which reinforced her sense of belonging to science. Unlike Diane, Demi described her integration in science not as a student but as a 'staff'. For Demi, "when nobody knows you, you are treated as a student", when you prove yourself and "have a role as a researcher they treat you as a staff". Demi's sense of belonging was influenced by how senior members viewed her. She often refers to senior members of her research community as 'they' (professors, PIs). She commented:

> *Me: Do you feel that you are integrated into your discipline?*
> *D: Yes, I am officially a staff in the research, so I have the role as a researcher and in the beginning when nobody knows you and nobody knows what your skills are, you are treated as a student But then when I tried to prove myself straightaway, I did extra work, I did extra hours just to prove to them that I am worthy to be there. And now they saw my potential, they see how I work, they treat me as one of the staff. They treat me like, you know, Now I do feel like I am integrated into the science field.*

Molly (BA) stressed the importance of participating in science groups in order to develop a sense of belonging to science. She told me that she had a very supportive and encouraging science group in high school that she attended regularly. Surrounded by a group of people who do and love science in high school had a positive effect on her attitudes towards science in general. She commented:

> *I had a very encouraging little group like I had a very encouraging support system, I guess where I really loved science. I was around people who loved science and saw the passion that I had. If I hadn't had the encouraging support system that I had as a teenager, I don't know if it would have ended up in physics.*

During the interview, Molly said to me several times that she had a big passion for science, particularly for physics. However, in the conversation above, she linked her participation in physics with an ‘encouraging support system’ she had in high school. From this statement, it can be seen that not only her interest in science but also her engagement with a science community (a group of friends who love and do science) contributed her sense of belonging to science and eventually to her choice of studying physics at college.

Molly's life changed a little during her first two years of college. At college, she described the physics environment as ‘not a women-heavy field.’ She had expected it, but it was still discouraging. She defined this as a problem in her early years in college, but once she found a support system just like she had in high school, she felt more comfortable. She commented:

> *When I was in my physics classes at college, I was aware that particularly physics is not a very woman heavy field. I guess it wasn't shocking to me, but at the same time, it was not overwhelmingly encouraging. I think that is particularly more of a problem earlier on in like the first two years, but it is a relatively small class, so like it is not as bad now. We can kind of support each other. So, it is not as bad now as it would have been.*

Molly’s repeated use of ‘encouraging’ and ‘support’ indicated that she valued the communicative and cooperative (team) aspect of science. In order to build a sense of communal attachment, she needs support and sharing and collaboration.

Like Molly, Ale (Ph.D.) described her environment in physics school as ‘encouraging’. She stated:

> *I am very comfortable here. The people are very nice. They are very encouraging. I am into outreach activities. We have an optical society here that we're part of. We were all students and we do activities for students and it can be competitions.*

Ale's description shows that being a member of an optical society at school and organizing some activities helped her develop a sense of community within her department and made her feel ‘comfortable’

Chloe (BA) and Sophia (Ph.D.) both indicated that they were well integrated into the scientific community at school, similar to Ale.

> *I feel like I am well integrated into a group. I would be able to talk to anyone. I would be able to help anyone ask anyone for help that is in my class. (Chloe)*

> *I have been lucky on being like in a group that actually makes me feel comfortable and valued. I honestly feel been lucky. (Sophia)*

Chloe stated that having interpersonal relationships in which she could ask for and provide help in the classroom made her feel well integrated into the small physics community she had. Sophia emphasized that she feels ‘lucky’ to have such a research group that she could feel comfortable and valued. According to Good et al. (2012) one’s sense of belonging involves his/her personal belief that s/he is an accepted member of an academic community whose presence and contributions are valued. Sophia's statement indicates that she feels ‘valued’ and ‘comfortable,’ implying that she has a strong sense of belonging to her physics school's research community.

Similarly, Dee (postdoc) indicated that she has been lucky in her research community thus far. She did, however, assess it from a gender perspective. She attributed her luck to people's disregard for her gender. Dee was implying gender-blindness rather than gender awareness here. In her case, she benefited from the workplace's disregard for her gender. She emphasized that as a woman she had not experienced any struggles in her work environment because she worked with ‘good’ people. On the other hand, she did not generalize her experiences. She differentiated her from other women who may have lots of struggles due to their gender.

> *I feel very lucky that I have always had very… and cause I obviously I predominantly worked with men, but those men had been like very good people to work with and had not seemingly cared about my gender, which is good because I have heard lots of stories of people who have like, you know, had bad times. And you would attribute that probably to then being women.*

During another postdoctoral researcher's interview, she mentioned that she had witnessed what Dee had just said. She recently attended a conference in her field. The speaker, who was a well-known member of her research community, began by discussing the field's future and the major issue for him, as Lou put it, "the feminization of the field." From Lou’s own narrative, the story is as follows:

> *He said that too many women were coming in and that for him, women were not fit to go on the field, and they were not as strong as men. And the second thing was that we were doing too much modelling and that we should not rely so much on computers and we should still go more in the field. At first, I was really shocked to hear that. And I felt super bad hearing him especially. I thought it was a joke at first. I was waiting for the end of the joke, he was super serious. So, I heard afterward that people were still shocked by what he said, but nobody, nobody called him out.*

At the time of the interview, Lou was a postdoctoral researcher in Geoscience (Earth Science). She stated that the scientific community is very important to researchers because they present their findings to the community and strive to do well. She went on to say that some members of the community, as evidenced by the example above, may be biased against women.. Lou said that she had experienced the same behaviour at the scientific conferences as well. She commented:

> *Sometimes some researchers or my advisor would talk more naturally to the guys in my department, even though they are Ph.D. students. I have realised that they would not look at me and they would talk to the guys even though I have more expertise on the questions they are asking.*

Lou's narrative is interesting because it addresses gender-based discrimination in terms of being respected and valued in the scientific community. Unlike Dee, Lou had some unpleasant gendered experiences in her research community. She brought up gender issues right at the start of the interview, as she talked about her experiences as a woman in her own discipline. She did say, however, that the research centre with which she was working was very helpful in making the members feel welcome.

Aine (Ph.D.) told me the same issue that Lou experienced in her research community. Aine has not herself experienced that but she heard it from the professors she was working with. She mentioned:

> *I have heard that I know a couple of professors who are female, and they go to conferences and some people ask them where their supervisor is or things like that. And they are the supervisor and that is their group and those are the Ph.D. students. So, like a lot of things like that happen where people automatically assume that you are the female. So, you must be the junior member and they are looking for your boss, but you are the boss. So, I think that does still happen a lot.*

Similarly, Ale reported the same issue with the physics community at academic conferences. She commented:

> *I am in a mixed field between medicine and physics. So, I do ophthalmology. We go to conferences that are a mix of ophthalmologists, which are doctors and then other conferences that are only physics. If you go into anything medical, you see a lot more women. But if you go into something that is pure physics, you see much, much less. I love the physics part because I like physics. So, conferences are excellent, but when you hear these comments, it is really, really frustrating. I have worked really hard to be where I am, but they put me down because I am a woman. It is about the comments I hear, for example, when we were walking with our supervisor, people said oh you are all very well accompanied and kind of that we are all women when with one supervisor who is a man and kind of like we are just keeping him company or answering questions.*

In her narrative, Ale mentioned the disparity in gender balance between the research communities at medical and physics conferences. She expressed her dissatisfaction with the comments she heard at these conferences, not because the physics community is heavily male-dominated. She described the conferences as ‘excellent’ while the comments of people in the conferences ‘frustrating’.

I concluded from her statements that she was unconcerned about gender issues until she was made aware of her identity as a ‘woman' at the conference. She had the impression that she was accompanying her supervisor with her other female colleagues because of other people's comments. She labeled this feeling as 'frustration.' She went on to say that she had worked extremely hard and earned her academic position, and that she was there not to accompany anyone but to present her findings to the physics community.

Ale, on the other hand, is very comfortable and integrated within her own disciplinary community at her college's physics school. She was a part of optics research groups where the other members were all PhDs or postdoctoral researchers. She felt isolated and disappointed in the larger physics research community at conferences, however.

Neha and Samiya were in the same research group as Ale. At the time of the interview, they were all doing a Ph.D. in Optics in the School of Physics. Both Neha and Samiya indicated that while they liked the optics study, they were uncomfortable in the social environment because of their ethnic and religious backgrounds. Below is the conversation between me and Neha first, and then between me and Samiya.

> *Me: Do you think your department is diverse? Do you feel comfortable?*
> *N: Yeah, I think so. I feel it is quite diverse. There are lots of international students and yeah, I feel ok.*
> *Me: Do you think the scientific community, in general, is diverse?*
> *N: I don't think so. I come from Bangladesh. When it comes to like competing with European people or American people, they underestimate you. I don't know if you understand my point of view, they think that you know nothing. Even if you are telling something right, they make you feel like you know nothing. I think with some people they have this kind of mentality even with my Ph.D., this is one struggling part because I think I am from that background, lots of people think that they know far better than me just because they are from developed countries. So, that thing is there, and I am facing that all the time. When it comes to women the general idea of people that they know less than men do. And when you are such a background like me, if you come from a very small country from Asia, people think that you know nothing. Even when you are trying to achieve something people always try to make you feel you are doing shit. I experienced that. So, this is also not because of being a woman but also because of your background. (Neha)*

> *Me: Do you feel that you are a part of the scientific community?*
> *S: Not fully, sometimes I feel like because of where I am from, my background, and like as a Muslim, I feel not very well integrated.*
> *Me: So, people see your background rather than your work?*

*S: It depends on the people. Some of them just pass by the way you look. They would not even stop and talk to you about your science just because of the way you look. (Samiya)*

From an individual perspective, both Neha and Samiya enjoy doing science from their early years. From a community perspective, they have been feeling isolated by their minority status. Both Neha and Samiya think that they are not well recognized and valued by the science community around them because of their ethnic and religious background respectively.

Neha explained that the research community at her college is diverse. She attributed diversity to international people's presence. She expressed her satisfaction with being a member of such a diverse international group. She did, however, make an important point about the differences among this "diverse" group. Neha stated that coming from a small Asian country has influenced how other people, particularly those from developed countries, view her. Despite the fact that her college research community is diverse, she expressed her dissatisfaction with her lack of equal respect and value. Her statements reveal that she has been carrying the burden of coming from not a 'developed' country, as she claimed, because even when she makes a claim, people make her feel like she 'knows nothing.' In their analysis of science identities of successful women of colour, Carlone et al. (2007) came up with an argument that "recognition by meaningful scientific others" is a key component of science identity. Neha's 'recognition by meaningful scientific others' is disrupted by the fact that not only she is a 'woman' but also she is a 'woman coming from a small country in Asia'.

Samiya told a similar story that she is not fully recognized by other people because of the way she looks. Samiya covered her head which is a sign of practicing her religion which may be different from most scientists. In her case, this brought her a conflict between some members of the science community and her as her 'science' is disrupted by her other people's bias about the way she dresses.

Amada who had just started as a postdoctoral researcher working on biophotonic expressed that she is not represented as a woman in her research group, but not as an Indian woman in the general physics community. She commented:

> *In terms of ethnicity, I cannot say that I am well represented in physics, but there is a good number of women here.*

Jill was the third year of Ph.D. working in a computational chemistry group at the time of the interview. She said she felt like she was in a bubble at school because there were so many people from different countries. Her school is diversity made her feel comfortable. She stated that she needed to prove herself outside of school. However, as we talked more in detail, she expressed that "only when they see your work, then they leave the stereotype behind". In her talk, 'they' refers to any people whom she presents her works/research.

> *J: They may judge you in the beginning, but then once they have seen your work, they are convinced by your work and they leave the stereotype behind.*
>
> *Me: What is the stereotype? Why do they judge you?*
>
> *J: Because I am a woman and I am from a country that has a poor education. They probably don't know how my life and education were there.*

Jill's statements like 'they may judge you', 'they are convinced by your work', 'they leave the stereotype behind' clearly show that from her perspective there is a black line between whoever 'they' are and her as if 'they' are the authority. Jill attributed the 'stereotype' she had to face to 1) being a woman, 2) ethic/national background.

Similarly, Diane is aware of the boundaries of the physics community, "*In physics, there may be very few women, but there are also very few people from ethnic minorities or economically disadvantaged backgrounds."* Her statement makes it clear that her description of the physics community as a whole is inclusive. She mentioned earlier in our conversation that women and other under-represented groups should take an active role in college science communities.

Dora (BA) distinguishes out from other participants because she refers to physics as ‘individual work’ rather than ‘teamwork.’ At least during her undergraduate years, her emotional attachment to physics is stronger than her community attachment to science. This emotion may have been triggered by how she felt excluded by others.: “*I was always going to drop out of physics in the first year because of how everyone made me feel about myself”*. She was in her last year of undergraduate in physics with biomedical sciences at the time of the interview. She did not drop out of the course, but she was not fully integrated with the physics community in her college. She commented:

> *Me: Do you feel that you are well integrated with the physics community in your school?*
> *D: I think I built that myself. It is not like they were very, what is the word? They are very accommodating. They are like, you know, we appreciate you that you are a girl in physics. It is not like that. I think I built myself up to feel like this. I just did all the work that I was myself.*

Dora placed a greater emphasis on her individual effort in physics than on her sense of belonging to a physics community and acceptance in her own disciplinary field at college.

Four key factors were found to contribute to the sense of belonging to a scientific community for the women interviewed: supporting, sharing, and collaborating. Additionally, they highlighted these feelings to describe belonging to a scientific community: being respected, valued, recognized, and accepted by scientific others. The narratives of the participants revealed that the women felt a sense of belonging to the scientific community. However, this is not the case when it comes to developing an interest in science in order to construct a science identity. When they encountered negative experiences in their scientific communities, none of the participants said they were discouraged from doing science. On the other hand, they reported that their enthusiasm and interest were increased when they had a supportive scientific community system. Additionally, I have found that women from underrepresented groups are less likely to feel they belong. These findings draw attention to the structural and cultural features of scientific communities in higher education that continue to favor white western males. Despite their feelings of being undervalued, recognized, and accepted by others, they persisted in their science majors. As previously stated, their personal interest and motivation are so high that despite a negative sense of belonging, they continue. All the women who were interviewed primarily connected their science identity to their personal interests, passion, and competence to science. They made a personal connection between their field and themselves rather than their personal relationship with scientific others and their science identity.

**Theme II Doing science**

Science identity construction was discussed in the literature review chapter in the context of a sense of belonging and performance. In the context of this research, performance refers to how participants participate in scientific activities, how they perceive scientists, and how they perceive themselves as scientists within their academic discipline. As I mentioned in the literature review chapter, I consider identity to be a dynamic and ongoing process, which means that identity encompasses not only what one is 'being' and 'belonging to,' but also what one is 'doing' and 'becoming.' So, people create identities; they form, shape, and manifest them through a variety of interactions and actions.

The subthemes which were developed as a result of a detailed analysis of the narratives are as such: (1) constructing the boundaries of a scientist, (2) the stereotypical image of a scientist, (3) scientist versus physicist (4) no more stereotypes, (5) the 'nerd' image, (6) I am not the typical physicist girl.

Participants' perceptions of scientists, depictions of themselves as scientists, and how both depiction and perception of scientists are related to how they do science were the focus of the interview questions. During the analysis, I discovered that how participants describe a scientist is inseparably related to how they conduct science.

They used their own experiences to illustrate what a scientist is and what skills a scientist should have

The term ‘scientist’ refers to a ‘science person’ within the participants’ own disciplinary domain. It could be a physicist, chemical scientist, physical scientist, energy scientist, astrophysicist, medical physicist, earth scientist, in brief, a person who does science within their particular academic disciplines.

***Constructing the boundaries of a scientist***

When asked to define a scientist, the most common words used by the participants were: creative, hardworking, determined, passionate, curious, patient, and inquisitive.

> *Maybe just inquisitive and interested. You have to be like asking questions all the time. So maybe that is probably like an enthusiastic. I suppose you have to be creative as well. (Dee, postdoc)*
>
> *You should be a patient person. Sometimes you have to wait a lot to get results. You have to study and study and go deep (Carol, postdoc)*
>
> *I am gonna say a lot of hardworking. I think for physics certainly because of the problems you have to solve. I think you do have to be quite creative to apply different things to solve the problem or like change the problem around to apply different types of maths to it. I think you might really be better to be emotional about your problems, like passionate about them. (Joan, BA)*
>
> *Creative, because you have to come up with creativity in the sense that you need to have initiative when something goes wrong, and yeah maybe see what is going wrong. Also, hard-working, ambitious, and passionate. (Annie, BA)*
>
> *For me being a scientist is just, you know fulfilling the objective of what work she wants to do, hardworking and dedicated… I am very dedicated to my work. I might go wrong in some places, but I would have the confidence to come back and correct it at that particular point. (Shalini, MSc)*
>
> *Scientist, for me, is patient, hardworking, determined, and passionate. My work is really experimental and let's say you are trying something you are*

*not getting results. You are trying because I build my optical setup and I rebuild my system may be more than a hundred times to get like less than one result. It is tiring. So, you really need to be patient and the time is very limited so you really can try to keep trying on things like for a long, long time That is really challenging, it is stressful.  Sometimes I don't have any weekends. I am working Saturday, Sunday on labs. You need to be productive, if something is not working, even at home, I cannot relax my mind. I try hard to get my job done. I think I am very patient. I love it. Otherwise, I would not survive that long. (Neha, Ph.D.)*

From the participants' perspective, a scientist is someone who works hard at whatever they do, who can go deep and never gives up, who can think creatively, and most importantly, who is passionate about science.

Ramya (postdoc) expressed that "As a scientist, you need to ask how, why, when, what" Saranya got specialized in chemical engineering. She was working on filtration materials in the School of Physics as a postdoctoral researcher at the time of the interview. During the interview, she emphasized that she feels more like an engineer most of the time as she wants everything to make work as a 'typical' engineer from her perspective. But she emphasized that she feels scientist when she tries to understand the core of something. Science makes her 'go deep' and ask questions. She commented:

*I am also a scientist. I chose filtration as my core field which we call material, which is a filter. So, it is almost a kind of physical separation. That is why I put into physics because all the basic principles are about physics.*

Lou (postdoc) studied engineering like Ramya, but after completing her master's degree, she decided to pursue a career in science. When I asked if she felt like an engineer or a scientist, she responded:

*Me: Do you consider yourself an engineer or a scientist?*
*L: As a scientist.*
*Me: How do you describe a scientist in your academic discipline? Do you think it is ideal for you?*
*L: I love being outside and like it was the ideal because in Geoscience you go on the field a lot, but you still do modelling and so on. There is an outside*

*part like you have to be out in the field often. So, I still go out in the field even though not as much as during my Ph.D. It can be quite physical as well. You have to be tough. You have to be outside. You have to be able to carry stuff and you get dirty because you are outside, and you are working a lot.*

Lou stressed the importance of being outside and working hard as well as modeling when describing a scientist in her own field. She described being outside as a "physical" activity that requires a person to be "tough." Lou clearly meets the basic requirements of a geoscientist because she stated that she ‘loves being outside (in the field)’. Being a scientist, in her opinion, is not a gendered occupation. However, as seen in the discussion below, scientists in her field participate in gendered outdoor activities. This was because geoscience is associated with outside work that requires physical strength, and physical strength is associated with masculinity. She commented:

*I think there is this perception that we are not as competent and skilled. I really feel that because for example, even with the guys that are not toxic and not having this kind of perception, like I feel sometimes they would think you are maybe good, but the guy would be better.*

Ale (Ph.D.) began her career in engineering, but after becoming interested in optics, she decided to switch to physics. She earned her bachelor's degree in physics and then went on to pursue a career in optics. All you need, according to Ale, is passion, curiosity, and a commitment to science. She said:

*A: I think for science, what you need is passion and that is the emotion to love what you do and be curious about what you do.*
*E: How can you describe a scientist in your field?*
*A: It is definitely hardworking and dedicated. I don't know anybody in science for the money at all because we don't get paid huge amounts. You are not going to become rich as a scientist.*

Throughout our interview, she repeatedly stated that she pursued science because she was passionate about it. Her enthusiasm stems from her love of science. She enjoyed the lab's experimental side of science the most. She commented:

> *I went onto my masters and did my masters project in optics, which was in the lab and actually partly with a company, but it was new research and I loved it. My project, kind of, flew by. I did not feel the pressure. I didn't feel the stress. I was really enjoying what I did. So, then it is kind of, if I enjoy being in the lab and enjoying the research project then Ph.D. would be good for me. I have never regretted it.*

Ale's description of a scientist is compatible with how she is doing science. Her way of practicing science, particularly physics in her case, shapes what it means to be a scientist. Just like Lou, Ale commented that physics is gendered and stereotyped. She used 'weird physics geek type' when she described the stereotypical image of a physicist. She distinguished between a scientist and a physicist here, but not from her own point of view, but from that of others. It is clear from her statement below that the stereotype of the physicist as a "weird geek" is gendered and attributed to men, which is partly due to the fact that men outnumber women in physics. She expressed:

> *Physics is kind of left alone to the weird physics geeks type thing. And they don't normally see women in that field. So, when we do appear there, then there is always kind of like just comments that you know, that they would not tell men.*

The participants' personality traits that describe a scientist are largely based on how they do science and how they are expected to do science. They frequently use neutral adjectives to describe a scientist's personality traits. However, Ale mentioned the 'weird physics geek type' in the last interview excerpt, which she distinguished herself from. In her description, 'geekiness' and 'weirdness' in physics or science carry gendered connotations. In the discourse of physics studies, geekiness is the negative characteristic of a physicist position that Ale negotiated. Women's participation in physics, from Ale's perspective, may transform this description at some point.

***The stereotypical image of a scientist***

It is notable from the excerpt below that Annie's description of a scientist by personal traits is neutral, however, when it comes to physical appearance it is stereotyped. In the following excerpt, she described scientist as a 'white old man in a lab coat'.

> *When you think of a scientist you imagine like a white old man in a lab coat you know …so maybe sometimes you can feel like you don't really fit in that stereotype, I don't know maybe you could think like oh this is not for me, because I am not typical. I would not be the typical scientist we are all used to seeing.*

As her statements illustrate, 'the typical image of scientists' is developed by seeing many examples of scientists who fit in this description. Annie expressed that she is 'not the typical' scientist that people are used to seeing. Notably, Annie resisted the typical image of a scientist, because she did not construct this image by herself, however, she did not show any resistance to the typical characteristic of the scientist she described because she constructed it by herself.

In Aine's (Ph.D.) account, the stereotypical scientist in her academic field looked similar to Annie's description. She commented:

> *I think the stereotype is like Albert Einstein, white hair glasses. That is probably the image. I have to say that when you go to some conferences that the majority of people are old, white men and they are in those senior positions.*

Aine's description of a (stereotypical) scientist, like Ale's, is directly linked to the physical appearance of the 'Albert Einstein' type of 'old white men' she frequently encounters at conferences. As a result, the picture is masculine. Her personality traits description of a scientist, on the other hand, is gender-neutral. Aine stated in the following excerpt that scientists in her academic circle have both differences and similarities with one another. Aine describes the common trait of a scientist as having a 'inquisitive nature.'

> *We are all so different and some of us would not be friends if we didn't have this one commonality. We think about things so differently. Some people are very social, some people are really horrendously not social, but I think like probably a lot of the people would have an inquisitive nature about*

*them, kind of wanting to find answers to questions and not happy to just sit back and accept things. You want to know how and why and you know, maybe in an inquisitive nature, but I think that is common in all the sciences.*

Aine's description of scientists pointed to the notion that scientists regardless of their disciplinary area never 'sit back' and 'accept things'. On the contrary, they would be eager to 'find answers.' From her statements, I can see that scientist is someone who always asks questions and wants to go deep of something. For Aine, this is the commonality to bring scientists together even if they may be so different from one another. When asked how she would define herself as a scientist she replied:

*It is struggling. You know, it is funny, I don't even know whether I would call myself a scientist. I still consider myself a student. I like constantly learning when someone asks me, I say I am an astrophysicist, but I would say in the last six months I have finally kind of found my feet a bit more in science. I think in the first few years of my Ph.D. I have had a really, really difficult, and I am kind of, you would go to meetings and you'd be kind of very much learning from people. We have like group meetings with our whole research group. And you don't know what to say or whatever. And I recently got the question comes up, I feel like I can answer.*

To Aine, being a scientist also entails being fully competent in what you do and what you know. In this sense, she still thinks of herself as a Ph.D. student who is still learning. You would feel more competent if you learn in depth and can answer and ask questions, as Aine has been doing for the past six months. She expressed this feeling as such: "*I have finally kind of found my feet a bit more in science."* Her science identity is being constructed, as can be seen from her statement, by doing science and being competent in it.

Just like Aine, Nicole is in astrophysics. She was the third year of undergraduate in astrophysics at the time of the interview. Unlike Aine who preferred to progress in academia, Nicole was leaning more towards the industry as she said she was more interested in 'hands-on stuff'. She commented:

*I am always more interested in the hands-on stuff, so like experiments and stuff. I don't know how much you do in academia, actual making things work, you know. I know from my experience in the industry, you do a lot of programming to try to make things work and stuff, which I think is really cool.*

Nicole took a more "experimental" approach to science. She's separating herself from academic research. Nicole told me how she was drawn to the experimental side of science because she thought it was ‘cool.’ Her description of conducting experiments as ‘making things work’ demonstrates her appreciation for both practical and analytical abilities. She said that during the internship when she saw people making an invention, she got interested in it and developed her own depiction of scientists out of it. When I asked her if she felt like a scientist, she right after told me about her internship and provided me a depiction of a scientist as someone who ‘does inventions’ and ‘creatively solve a problem’. Here, she emphasized that problem-solving, from her perspective, is solving physical problems such as building and inventing something. She commented:

*Me: Do you feel like a scientist?*
*N: I do feel like I am on the way. Especially this internship… I see people do their own inventions, making their own stuff. I am like, that is kind of cool, you know.*

*I would say a scientist could be someone who can creatively solve a problem, but not like this is the way you probably be a problem solver in your own perspective. Like physical, like do stuff, like making computers work or making a problem that we need new technology work or anything like that. Like physical problems. I do like the image at those that make me feel smarter than I feel, you know. I do enjoy having physicists as part of my identity.*

Nicole portrays the image of a scientist in her discipline as someone who works on physical problems and solves them creatively, as evidenced by the discussion above. This image of a scientist makes her feel smart and, most likely, motivated. She stressed the aspect of science that she identified with the most: ‘ solving problems.’ However, she, like other participants, provided a masculine portrayal of a scientist when it came to the physical image of a scientist. She commented:

> *It is like if it is taking of either a crazy, old, bald scientist, boring all about it… old crazy white men when you think of physicists. I think it is slowly changing, and I definitely do want it to change.*

It is worth noting that she first described scientist as a ‘crazy, old, bald’ person, particularly physicists as ‘crazy, white, men,’ whom she considers ‘boring.’ Her ideal image, on the other hand, is of someone who invents, works on real physical problems, and solves them in a creative way that she finds ‘cool.’ As a result, she gave me a ‘boring' versus ‘cool' image of a scientist, the first of which is described solely by physical appearance, while the second is described solely by personality traits.

***Scientist versus physicist***

Scientists are be depicted differently than physicists, according to the participants, especially in terms of physical appearance. The participants' general perception of a physicist is more masculine than their general perception of a scientist, according to the data. Demi expressed:

> *An image of scientists… If there is a woman, I would think that she is a biologist and I would think that she is a medicinal chemist, or I would think that she is a medicinal physicist. I would not think that she is, you know, a physicist like an energy physicist. Oh, we have some brilliant women, but it is mainly men. The women would be in material science. They would be in medical physics, like devices and stuff and then like, vacuum technology, and optics, but it would not be energy.*

Demi views the physics discipline itself as being made up of various sub-fields where women are less or more underrepresented. In her view, even if there is a woman in physics, she would not be in an energy field where Demi herself was studying. So, rather than portraying a stereotypical image of physicists from the outside, she was going through her own visualization. If there is a woman in it, Demi drew a gendered line between scientist and physicist, and even between energy physicist and medical physicist.

When only describing the personality characteristics of a scientist, Diane and Julianne attributed neutral features to scientists and physicists. When it comes to physical images, however, they both distinguish between a scientist and a physicist in terms of the image in their heads.. When asked how to describe a scientist Julianne (Ph.D.) said:

> *I guess like when I think of just the term scientist, I would probably picture biologists and maybe a woman. But if I am picturing a physicist, I would picture a man. When people are talking of discoveries, it is just like male names. When people ask me what I do, it is always in my mind that I am a girl and they are not expecting me to do physics. That is what bothers me.*

Julianne's image of a scientist and physicist is shaped by the number of female scientists and physicists she has seen or heard. She stated that she had only heard of 'male names' when people were discussing discoveries. In addition, she has noticed that when people learn that she is a physicist, they are surprised. Because she's a physicist and a 'girl.' It is a rare combination in the eyes of others. What bothers Julianne is that gendered image which she cannot fit in.

Diane (BA) described a scientist as a person, but she described a physicist as a man. Her physical description of a physicist is also developed by seeing men around her as physicists. That is the typical picture she sees in her department. In order to depict a physicist, she used the terms 'male', 'assertive in their opinions', 'lecturer' which is masculine and patronizing, while in order to depict a scientist the terms she used were 'person', 'white coat', 'working hard' and 'researching' which is gender-neutral, experimental and analytical. She commented:

> *Well, when you say physicist, that has a slightly different like stereotypical image in my head than a scientist does, I mean when you said scientist, I was thinking, oh, just a person, white coat and you know they are researching and they are working hard. But when you said physicist, it suddenly became a man in my head, which is interesting. I probably think*

> *more of my lecturers here who tend to be like a male, very assertive in their opinions, or maybe stating things as facts when they actually are not.*

Diane self-identifies as a physicist. A physicist, she said, needs a good mix of imagination and logic, as well as the ability to think critically. She expressed:

> *I would call myself a physicist because I like physics more than I intend on doing other sciences. You need to be a good mix of logic and creativity and know when to apply logic and where to. And I think learning to do physics well is learning to think in a critical way.*

Diane depicted physicists who leaned heavily on lecturers in her field, but this description runs contrary to her own self-identification as a physicist. In other words, the discourses Diane constructed of herself as a physicist and the ways she presented images of physicists were incompatible. Her ideal image of herself as a physicist differs from the stereotypical image she described earlier.

***No more stereotypical image***

Some participants stated that their perception of scientists changed after they went into science. They described scientists according to how they do science. It can be seen from Kathryn's comments below that the appearance of a scientist in her head once was 'fuzzy Albert Einstein hair man in a white coat'. That was most likely the picture she saw in books, on television, in the media, at school, or elsewhere. She came up with her own description based on what she saw in her scientific setting. A scientist, according to her, is someone who is 'interested in discovering new things,' just as Kathryn is.

> *When I was a kid, I would definitely have just called a scientist as a man in a white coat, which, you know, Fuzzy Albert Einstein hair. I think it changed the more I saw people who didn't fit them. So, I used to think, well, probably a scientist is like a guy in the white coat, but now I am like, a scientist can be anybody. My description of a scientist would be someone who is interested in discovering new things. I got to find out cool things about how the world works and I am like, well that is exciting.*

Lara depicted a scientist as someone who 'works away at a computer' and 'try to understand event the tiny piece of a bigger problem for months'. Her description of a scientist is influenced both by the way she is herself doing science and the way other people are doing science around her. She expressed:

> *I do theoretical astrophysics. So, I just work at a computer all day. My view of what a scientist has changed so much. Like when I was a kid, I would have viewed a scientist as someone in a lab, someone building something and, and they were usually a man I was picturing. But then now I picture a scientist as just someone who is working away at a computer or like, you know, trying to understand an issue for months on end and doing this really tiny piece of this much bigger problem but out of very specific expert level. I think that is just because you know what I am surrounded by like you base this on your environment or your influences.*

As she was involved more in science Lara's description of scientists changed. Her view of a scientist was once a man in a lab building something. Then her view evolved to a non-gendered subject which is 'a person who works at a computer' just like she is doing which illustrates that she is constructing her own perception of a scientist as she is more engaged in science.

Similarly, April (MSc) claimed that after seeing various images of scientists around her, the physical image of the scientist in her head changed. April, like Lara, identified a scientist as someone who resembled her. She expressed:

> *I suppose for me a scientist is kind of someone who looks at something that maybe we do not understand that much, it is not really a physical image anymore because I have seen so many different images of the scientists, you know, so it is not like the old guy with crazy hair. I mean I have seen that, but that is not the typical image. It would be just kind of someone like maybe my age and doing research.*

After April went into science, the stereotypical image of a 'old man with crazy hair' was replaced with someone 'her age doing research.' This phrase also highlights the stereotype of a scientist as someone who 'looks at something we don't understand that much.' I suppose we applies to people who are not scientists. April's scientist image has not been gendered anymore. She did, however, draw a distinction between boys and girls when it came to expressing emotions while doing science. She said:

> *I would express emotions. But even we did like a field trip up the mountain and we were using like telescope and stuff and it was quite stressful. So, all of the girls on the trip had a little tear at one point or another. And it is like, guys just see this as like, you know, they are falling apart and we are not, we are just a bit stressed and that is how we express it.*

The way people express emotions, according to April, may differ depending on their gender.

When faced with a stressful situation during the field trip, she said it is always the girls who cry. However, she claims that this is not a weakness that causes someone to fall apart. It is, on the contrary, a way of expressing your distress. When I asked what kind of personality traits are necessary to succeed in her own academic field she replied:

> *I think you have to be determined because like I say, like physics it is doable, but it is hard. Like there are times, you know, where I don't understand something and you kind of have to push back the fear of like, oh, I don't know what I am doing and just play through and then kind of you will get there. It is just sometimes a bit kind of daunting.*

April described scientists in the previous discussion data as people who look at things that we don't fully comprehend. To be a scientist, especially a physicist, in her opinion, one must be 'determined,' that is, one must never give up even though one does not understand something. The words she used to describe physics as 'hard' but 'doable' illustrates that you need to be 'determined' to do physics.

Jill was in her third year of Ph.D. in physical chemistry at the time of the interview. Chemistry is thought to be more inclusive in terms of gender balance compared to physics. During the interview, Jill told me that the representation of women is higher in chemistry compared to physics. However, she said that *"the higher you go, the fewer women you see even in chemistry. Especially if you go up to higher-ranking at research, there are all men."* Jill stated that as she was surrounded by scientists in her research group, she did not have any stereotypical image of a scientist, because she had seen many different people. For people in higher positions in academia, however, her portrayal of a scientist is male.. She commented:

> *I think for people looking from the outside, there are more stereotypes than from people in science. But for example, if you ask me to think about a professor in chemistry or physics, a man would probably come to my mind.*

When asked what skills a scientist needs, Jill, like the majority of the participants, attributed neutral characteristics to a scientist, such as ‘independence and curiosity.’

> *I think that whoever wants to be a scientist needs to be very willing to learn new things and learn by themselves. So, independence and curiosity are necessary. I find a lot of meaning and purpose by doing research and by being a scientist.*

Similarly, Molly discussed how her perception of a scientist changed as a result of seeing various kinds of scientists during her college years.

> *I think my image of scientists has definitely changed from when I was a little kid. I have been in college for four years, surrounded by scientists. There are so many different types of scientists out there. And it is not like in my head now. When you were a kid, if you don't have a lot of exposure to all kinds of different types of scientists, then a lot of times the instinct is to say all the scientists, like, Einstein kind of the old dude. it seems boring, really boring. (Molly, BA)*

Before the college, she portrayed the image that was both gendered and stereotyped: ‘*Einstein kind of the old dude’* which seemed boring to her. Science, on the other hand, is full of fun activities and has always seemed ‘cool’ and ‘interesting’ to her. For Molly as a child, there was an inconsistency between the image of scientists and the science itself. From her statements above after she has seen different kinds of people doing science, she has overcome that contradictory image.

In her academic field, Molly described scientists as curious, passionate, and creative.  Particularly in physics that she was studying she stated that *"you have to be passionate and love what you are doing because in physics it takes so long to get from the initial idea to getting a* *result".* She explained that science is a process in which you learn more at each step and are satisfied with your accomplishments, even though you don't get the desired result on the first try. The way she is doing science is based on 'learning' and 'having fun'

> *The way that I look at science is that, even if the thing doesn't work out the way I want, I can still learn something. For example, my project this year. My conclusion was that it is worth doing more research on this. I was very excited about that result. I think having like just a fascination with every step of the scientific process of it.*
>
> *I am incredibly enthusiastic. I get very excited about what I am doing. I think one of the things that I learned about myself when I was doing my project earlier, I spent two straight weeks trying to get one integral to work and it just wasn't working. that was really frustrating, but also at the same time, I just kept coming in every day and was like, I am going to get it worked today. when it finally worked, I was so excited.*

Scientists are stereotypically portrayed as a white old Einstein type of man, according to the narratives under this subtheme, which revealed a contradiction. When the participants were asked about the stereotypical image of a scientist, they all indicated that it had been replaced by their own construction of scientists. They created their own kinds of scientists by adding their own implications.

### *The 'nerd' image*

When explaining what a scientist is, some participants used the term 'nerd geek.' For Chloe (BA) being a nerd, geek scientist is what she has defined herself.

> *If I were to find myself, I would be a scientist and also a complete nerd geek. That is what I defined this up.*

According to the conversation data, Chloe believes that physics is like a boys' club where you can see nerdy 'boys.' The word 'nerd,' as she used it, refers to a male who enjoys computers and video games. Chloe described her feelings about 'boys club' and 'nerd boys' as something that she has now overcome. Her statement 'I am happy with my gender and I am in that club' shows that the image of the scientist in her head as nerd geek is not gendered anymore.

> *I still feel like it is boys club because of the level, the social thing around it off, you know, boys are, can be nerds and they can like computers and video games. I have overcome that now. I am happy with my gender and I am in that club.*

Chloe portrayed scientists as methodical, unbiased, logical, and problem solvers, in addition to the 'nerd geek' image she associated herself with. She stressed the importance of being methodical in experimental laboratories in particular. Chloe's narrative represents a conflict between the need to be methodical in the lab as a scientist and the stress she has experienced in the laboratories due to her tendency to forget things. She is escaping the lab as a way of coping with the stress.

> *I think being methodical is very important from what I have felt in labs specifically as experimental labs. Methodical, logical, unbiased. It is very important to get your data and look at your data with a completely objective view. Problem-solving is basically what we are doing. We learned how to actually verify this from experiments. You know what values do we take? How can we set it up? You know, we have to look out for things that could, you know, screw up things. During the labs, I tend to forget a lot of stuff. I forget to take a measurement here, forget to take the air here, and then, you know, when I am writing up the lab, I genuinely don't have labs. I told them I don't like the stress because I know that I am going to forget something. It is a challenge. I do like class though.*

Sophia (Ph.D.) described herself as a nerd. She did not specify a gender for it.

> *Even though I would not look like so, people consider me very nerd. Okay. I like it. A real one, like the one who does all the things in the Big Bang theory. (Sophia)*

Later in the interview, she defined a scientist as someone with an experimental and logical mind, similar to herself. She claimed that the moment she walked into the lab, she knew that was the path she wanted to take in science. She possesses all of the characteristics that a scientist must possess.

Cuca (BA) described a scientist as a nerdy person who conducts experiments and solves problems, which she finds to be a lot of fun.

> *A scientist is someone who wants to solve problems, find answers to things, and conduct experiments, looking for those answers. Someone who does experiments, blowing things up. Fun stuff. Very nerdy.*

The data from the interviews suggests that being a nerd is a positive trait. Sophia, Chloe, and Cuca loved the idea of being a scientist while being a nerd. They associated the word 'nerd' with words like 'I like it,' 'fun stuff,' and 'if I were to find myself...' On the contrary, Ale (Ph.D.) said that "*physics is kind of left alone to the weird physics geeks type thing, they don't normally see women in that field"*. From this statement, it is clear that Ale does not identify as a 'geek,' and therefore the term 'geek' has no positive connotation for her because it contains no woman, in her opinion. Similarly, Kelly's (Ph.D.) refusal to associate herself with the image of a 'nerdy scientist' suggests that the idea of a scientist as a nerd can be viewed negatively.

> *K: I suppose I like to find myself as kind of a scientist who doesn't look like a scientist.*
> *Me: What does a scientist look like?*
> *K: I mean the female professors like they kind of would be more of that stereotype like they are really nerdy.*

All of these comments suggest that a stereotype that one person portrays as negative and dismissive may appear positive and encouraging to others if they identify with that stereotype.

### *I am not the typical physicist girl*

Dora was the only participant I interviewed who described herself as being different from other girls, stating that she is not a 'typical physicist girl.' The remaining participants either compared themselves to a stereotypical image of a scientist in their heads, which they described as a 'Einstein kind of white old man with crazy hair' or created their own science person image without assigning gender. Dora positioned herself as an exceptional physicist girl, distinguishing herself from the majority of other girls in her academic field, as evidenced by the following conversation:

> *D: When I first came into the class, I felt like the boys are kind of looking at me like, what is she doing here? I am not a typical girl to physics. What really struck me was that when I went into the class the girls… like there was a lot of oversexualizing, you know, people kind of look at you and making an opinion.*
> *E: What is the typical physics girl?*
> *D: I think the one that you know is seen by everyone is just someone who doesn't look like me. When it comes to a woman, it is someone who maybe doesn't care so much about her appearance. I think that is quite real at times. Like yesterday we had someone we organize people coming in who did physics 20, 30 years ago in our course and talking about how their career has progressed. And the one that came in was just a typical physicist, you know, and like whenever I look around, I have just seen typical physicist girls, that is fine. That is just how it is.*

Dora noted a link between her physical appearance and her value and recognition as a physicist girl. In Dora's case, typical physicist women's descriptions tended to place a greater focus on appearance than behavior. She argued that the most important way to be accepted as a physicist girl in her academic circle was to take on the role of a stereotypical physicist girl as a subject. Otherwise, people would 'look at you like what are you doing here'. Dora described this social exclusion as a result of false 'oversexualizing'. Later in the interview, she said, "*getting through four years in the physics department at college, you have to have very tough skin.*" This is the way (having tough skin) how Dora would stand out from a physics community around her. Another way that Dora was able to position herself as a recognized physicist girl was to perform the subject position of the physicist by being active in the physics community as someone who breaks the boundaries of 'typical physicist'. Here, she emphasized the importance of existing as who she is.

> *I want to be very active in the physics community so people can look up and see this is a girl that is, you know, do all of this. She has been through all this, you know, and it is not as a typical physicist.*

Dora's method of subverting the 'typical physicist image' is by positioning herself in opposition to that image and being a role model as a woman who 'cares about her appearance' and as a physicist who is active within the science community.

**Theme III- Doing gender**

Theme III 'Doing Gender' describes the participants' understanding and experience of their gender identity, how they perform their gender, and their perception of womanhood as well as how they define and demonstrate their gender within the context of science. As a result of this investigation, the 'woman' factor has been highlighted.

This is the theme for which I have had the most difficulty arranging incoherence because gender performance is highly subjective. Gender is linked to the self, the soul, the body, and behaviors. It can be something a person discovers, realizes, rebels against, or accepts. A label, a presentation, a verbal expression, or an act may also be used. It can be made, replicated, constituted, called, reified, internalized, or born into. As a result of the analysis, I've discovered that words related to gender identity can be slippery, contextual, or situational. It is difficult to come up with a consistent understanding of gender identity, gender expressions, and gender performances, as well as a stable and consistent concept of womanhood. As Annie (BA) who is the youngest of the participants said, "***It is all in your head"***.

All the participants self-identified as a woman. It may not, however, be a true reflection of who they are, because it may be a choice or a particular gendered-label (whether female-identified or not) may have been validated at some point in their lives, and they perform it for that reason. Or they choose to present their genders because of an internal or external expectation.

Gender is a complex topic that is often influenced by personal experiences. This theme's goal is to avoid oversimplifying their gender identity. I would rather focus on how their expressed gender identity ("woman" in this case) functions at one point in their lives (at the time of the interview) and what it means to them, as well as how it influences their science identity.

Through discursive narrative analysis of the data with paying attention to the repeated codes, one main theme (Doing gender) and three subthemes were identified: (1) it is my personal journey, (2) girly girls & tomboys– girls doing femininity and masculinity, (3) negotiations of femininity in science.

***It is my personal journey***

All the participants in this research self-identified as women. However, what is performed as femininity can be perceived as not 'feminine' for some participants. What or who a woman is, from one of the participants' perspective, can be quite the opposite from the other's perspective. The definitional boundary of womanhood is vague.

Reese (BA) commented

> *What a woman is can be different than your definition of what a woman is. So, I would definitely consider myself female and in certain ways I am feminine but in certain ways, I am really not. I am perfectly fine fitting within my description of it where somebody else might have a very different.*

Reese's portrayal of womanhood does not conform to preconceived notions of what a woman should look like. Her definition of womanhood may or may not coincide with the definitions of others. Her definition of womanhood does not necessitate any specific feminine characteristics.

Dora (BA) associates gender identity with 'love' in terms of fluidity and flexibility. For her, just like love can change and get different meanings over time, being a woman depends on individual perception which may get a particular meaning upon particular life experiences.

> *I think it is similar to love. If you look at what love means to you, you take that kind of vague definition of, you know, how does this person love me. The reasons why someone loves you can be something at some point in time and then years later they can be different. I think it is the same thing. You know, what makes you a woman is very dependent on your experiences, I think. I think it is very dependent on your experiences and the things that have happened to you.*

Dora’s performance and expression of her gender identity as a ‘woman’ are in line with her ‘physicist’ identity. In the following interview excerpt, she identifies herself with a ‘strong physicist woman’. This phrase shows that there is a mutual positive interaction between her science and gender identities. These two identities empower one another which in the end makes her develop a strong science identity as a woman.

> *I do feel very strongly about being, you know, a woman. I think it comes hand in hand with being a physicist. If I was to describe myself, I would say a strong physicist woman*

Through the interview with Dora, she was always referencing to her ‘strong physicist woman’ identity. It can be seen from the interview excerpt below that the challenges she has faced as a woman in physics make up her unique experiences as a physicist woman. As she said above, what makes you a woman is your experiences. These experiences (as a young woman doing physics) constitutes her gender identity. Being a woman in physics, from her perspective, includes lots of independence and strength which she describes it as a ‘giant personal journey’.

> *Especially if you are a girl, you need to prove a bigger point. Maybe you might need to do more to have your voice heard there. No one is going to sit down and tell you those things. It is a lot of independence and so a lot of building over yourself as a giant personal journey.*

April’s perception of gender identity and gender roles is interesting. I preferred to discuss it under the theme of *it is my journey*, because After she got into physics, she changed her perspective on what it means to be a woman. April's gender and science identities, like Dora's, are inextricably linked. April did not separate gender from a gender role. In the narrative of April below, it can be seen that her participation in physics has changed the perception of traditional femininity in her head. In her early years at school, she was more leaning towards biology. Because she identified as a "girl," she decided to major in biology, where her gender would be better represented. Finally, when she decided on physics, she put her passion ahead of her preconceived notions of gender roles. Thus, as she explained below, ‘the context of how she sees her gender’ has also changed.

> *My gender, my role as a woman is changing. When I was in secondary school, being a girl was like kind of..., I thought like I will go into biology, and then I suppose as I became more into physics and stuff, I was like, oh, I can be a girl and do physics, I suppose. I don't know if my gender changes or if just the context of how I see my gender.*

In the interview, April told me that she gets annoyed at herself for being emotional because being emotional is viewed as ‘weakness’ by other people (not for her) and is associated with being a woman (for her). She expressed:

> *I think that sometimes being a woman is kind of annoying because I get annoyed at myself for being emotional. Being a woman is sometimes a bit more difficult because like being emotional is seen as weak. That is always kind of bothered me because I have always been a kind of, if I am stressed, I have a little cry and I get over it. I feel that that was viewed as a weakness throughout my undergraduate degree. We did like a field trip up the mountain and we were using like telescope and stuff and it was quite stressful. So, all of the girls on the trip had a little tear at one point or another. And it is like, guys just see this as like, you know, they are falling apart and we are not, we are just a bit stressed and that is how we express it.*

The narrative above is very interesting in terms of showing her internal conflict of performing ‘womanhood’ and her rejection of the traditional formulation of femininity (girls cry under stress). Because of the way women express feelings, she described being a woman as "difficult" and ‘annoying.’ Under stress, the way to express emotion is to ‘cry' for her. She linked it to being a woman primarily because she had witnessed numerous instances of this (girls crying) on a field trip during her undergraduate years. What frustrates her is not how girls express their feelings, but how her male friends perceive them. So, from her viewpoint, ‘being a woman’ is a social role identified by others rather than by oneself. It is perfectly acceptable for girls to cry.

She is not against the idea of femininity being associated with crying, but the belief that crying is seen as a sign of weakness.

In the interview excerpt below, Kathryn (Ph.D.) gives reference to the social construction of gender. Her statement ‘inside I feel like a woman, but also people treat me like a woman’ shows that gender identity is both innate to her soul and body as well as it is partly constructed by the interaction with other people. So, Kathryn is both labelled as a woman by other people and by herself too. However, she emphasizes that what it means to be a woman is subjective. She is challenging the women’s role defined by the gender norms by dating women and swearing like men. Although dating women and swearing are defined as a stereotypically masculine act or behaviour, she is subverting it by performing womanhood and masculine traits at the same time. She commented:

> *I don't have a problem with gender as an idea, but I have a problem with when people make rules around gender. Inside I feel like a woman, but also people treat me like a woman. Socially I interact as a woman as well. I have some friends who identify in the middle and so that makes me think about my own gender. I think that I am a woman. For a while, I wondered if I didn't identify as a woman fully because I don't always behave like society thinks that a woman should, you know like I swear, I don't know why I date women. but I think that for me, I get to define womanhood for myself.*

The narrative of Kathryn above demonstrates that gender roles, rather than gender expression, are the source of her problems. Kathryn's identification with the word "woman" can be described as both an internal way of seeing herself and a kind of interaction with the world around her, as shown below. She emphasized that being a ‘woman' is a learned skill. Kathryn commented:

> *It is an idea in society that women have to look a particular way. I think that you do learn to be a woman in some ways. In some ways, it is inside. I feel like a woman, but also there is so much that I have learned, I learned from my family and from society and stuff like that.*
> *I feel like a strong woman, I feel like a person who has my own opinions and thoughts.*

Kathryn, like Dora, positioned herself as a ‘strong woman.’ Dora associates the term "strong woman" with self-confidence and independence. With different words, Kathryn expressed the same characteristics of a strong woman.

***Girly girls & tomboys– girls doing femininity and masculinity***

Children are exposed to specific gender categories and gender roles from an early age. They are expected to act out their gender in ways that are dictated by the society in which they live. However, not all children follow these rigidly defined gender roles. They may exist outside of the traditional definitions of femininity and masculinity associated with being a ‘boy’ or ‘girl.’ It is possible that what they do differs from what is expected of them. Alternatively, they may refuse any labeling associated with their gender at birth. I examine the participants who identified themselves as tomboys or girly girls in relation to their science identity development under this theme.

The concept of girly girl and tomboy is a set of roles, behaviours, acts, or kinds of label and naming which is associated with femininity or masculinity. As such a restrictive labelling term *girly* and *boyish*, the boundary of doing girly or boyish is constructed by people. For me, these are such floppy things that I prefer to narrate it in the participants' own words, without adding my own interpretation.

Diane (BA) defined her gender identity as something assigned herself at birth that she never questioned. As can be seen from her statement ‘I felt that description fitted me’ she was not uncomfortable as she was viewed as a girl in the past. However, it is interesting what she said in the narrative below: “*if we were to start now and redefine things, we wouldn’t necessarily divide the world into those two categories.”*

> *I would say by the time I was like seven or something, I was like, no, I am a girl. Boys are yucky, you know. There was not a moment when I became conscious of it, but when I was young, I felt that that description fitted me you know. I never questioned that. I don't know if because we have evolved in a way that has given us these biological distinctions, we have defined a man and a woman. But if we were to start now and sort of redefining things,*

> *I don't think you would necessarily need to divide the world into those two categories.*

It is difficult to think beyond the gender roles that people are assigned in a binary world. Gender stereotypes based on 'two binary categories' such as man and woman/girl or boy can affect self-perception of one's ability and competence belief, as Lara's comment demonstrates. Girls are encouraged to be and perform as girly to fit into society's perception of what a 'girl' is, as Lara's comment demonstrates. As Lara's case, it took her longer to realize that she was particularly interested in science as it was kind of seen as a 'boys' thing. She commented:

> *I think if I had grown up, certainly if I had grown up as a boy, I think I would have been like building things like crazy and gotten even more into it and I would have been like, I am going to be an engineer. I am going to be a physicist. I am going to be a computer scientist by the time I was like 12. I think it took me longer to realize it because I was, you know, just with every year I got older, I was becoming more interested in what society thinks I should be as a girl. Like I wanted to be pretty, I wanted to look good and, and like impress people. think that is kind of, an element of just puberty and trying to fit in and be cool and stuff. (Lara, Ph.D.)*

Chloe (BA) stated that in her early years she engaged in activities outside of femininity defined by herself. Chloe described boyish activities as doing 'science', playing with 'robots' and 'dinosaurs', and personality traits as 'social' and 'never hold grudge'. She takes up a subject position in contrast to the girls in her environment who, in her opinion, have no interest in science.

> *I feel better being around boys. I never really liked girls. I grew up in the country and there weren't a lot of girls like me that were interested in all of this kind of science. I felt lonely there, you know, with the boys it is just they are fine with it. They are more social. They don't hold grudges or anything like that. They will laugh with you if you have a laugh with them. When I was a kid around a kind of 8 to 10, I had this serious phase where I wanted to be a boy. I felt so alienated by the girls because I was deeply interested in all of these things that were primarily boys'* things, science, dinosaurs, robots, all of that.

In her mind, what boys did at the time, as well as the image of ‘boys' in the media, created a kind of ‘girls versus boys' binary. The words she used, such as ‘I felt alienated’ and ‘I felt lonely,’ indicate that she was uncomfortable with the image of a girl in her head who, as she explained, loves pink and dolls. Chloe told me in the interview that she has always liked science, just like the other participants. She expressed her dissatisfaction with her grandmother's insistence that she follow certain feminine standards. Her reaction to it was described as ‘rebellious.’

> *And maybe it was my grandmother who lived with me as well and she is kind of, girls like pink and dolls. So, I could have been rebelling. There is still have an adverse reaction to anything pink or fluffy points. I watched cartoons a lot as a kid, probably older than I should have been. But on all these channels, it was all you know, male-oriented kind of cartoons and the adverts will all about, you know, the kind of prize and discussing things and cars, things like that. And then you go onto something for girls. I was just, you are, kind of a barrage of pink. You cannot really get out of that. I wanted to be a boy because of what boys were kind of either sold on TV or what they liked. You know, I wanted to be in with that crowd.*

Chloe's perception of what it means to be a ‘girl’ changed once she became accustomed to her body, or pretended to be accustomed to it, as she explained below:

> *I seriously wanted to be a boy when I was younger. I think something like that can change as you got accustomed to your body. Or maybe you have learned to pretend to be accustomed to your body. When you grow up you sort of realizing that, you know, I want to be me. There are many deeper things I would say.*

Everything she said can be summed up in the sentence ‘I want to be me.’ Chloe kept telling me throughout our conversation that being a scientist is a big part of her identity. Throughout the interview, she frequently stressed her science identity and stated that it is what defines her the most. Her interest in science as a child had a big impact on her gender perception. She distanced herself from the girls, as well as any kind of female identity, because she believes that the concept of a ‘girl’ is collides with science. Only she can define what it means to ‘be her.’ She described herself as a woman, as she explained below. But, for her, being a woman is no longer solely defined by the ‘social thing' that surrounds that identity. Instead, the body, or material self, is a reflection of who a woman is from her point of view. She loves her own bodily performances, which she associates with femininity.

> *... I would be female. I am happy with it now because I realised that the whole interest around it doesn't define me. It is this social thing. I am happy being a woman. I do like being a woman physically and visually as in my mind, my body, I like it. But I don't think being a woman kind of flows into my identity that much.*

Following Chloe's narratives, I would like to provide two examples that may contradict what she said. However, a closer examination reveals that it leads down the same path as Chloe. Both Julianne and Aine (Ph.D.) used positive language to describe their feelings about femininity. Julianne accepted a subject position associated with the girly girl when she was a child. Her acceptance was congruent with her desire to express femininity with stereotypical objects and descriptions. She described herself as a ‘pretty’ girl who enjoyed ‘pink, dolls, and dresses’.

> *I was pretty girly when I was a child. I don't know why, but I just preferred it, I liked pink and dolls and dresses. So, I don't know if that's something about me or it is just that I wanted to prove I was a girl.*

Stereotypical femininity and masculinity are imposed on children through any kind of communicative tool and by society, as Chloe previously stated. Julianne stated above, which I found very interesting and important, that she was unaware that there was something about her or that she simply wanted to prove she was a ‘girl.' Pink, dolls, and dresses were not necessarily signs that she was supposed to play a specific gender, but it was something she picked up along the way. She discovered that she had to perform in that manner in order to be accepted by that crowd of girls.

Femininity is embraced as a part of Aine's identity. She expressed herself through her emotions. She also positioned femininity, not in opposition to science. She commented:

> *I am a very feminine girl and also fantastic at science, but I don't feel I necessary to do either. I just do what I feel. And if it bothers someone, it bothers someone.*

Aine’s words seemed to include independence and active agency in terms of doing femininity and doing science. “The balance between doing girl and doing science is said to be difficult to achieve” (Archer et al., 2012; p. 978). They researched younger girls at the elementary level. They have concluded that “science aspiration sits in an uneasy tension with femininity and girls negotiate a socially acceptable performance of femininity that can balance their engagement with the aspects of science that are perceived to be masculine”. (p. 982- 983) In Aine’s case, she is older, and she is more aware of the gender roles and the stereotypically masculine image of science, especially of physics which is her academic discipline.

Aine described herself as a ‘feminine girl’ who is ‘fantastic at science.’ In doing so, she is challenging the long-held masculine image of science on the stage.

Demi’s (BA) narrative reflects what Archer, et.al explained above. Demi said that she “*does her hair, do make-up and dress nice”* which is associated with femininity. She performs femininity visually.

> *I am young and I go out to clubs and things like that and you know if I do my hair and I do my makeup and I dress nice and I meet someone they asked me first of all if my name is real, second of all they asked me if I am actually doing science. I am a woman and I am Lithuanian, you know, for someone coming from Lithuania, there is always like a coming here and working in a factory kind of stereotype.*

Demi’s narrative reveals how ethnicity and gender intersected with the bodily performance of femininity construct a gendered and racialized image in people’s heads. Demi, on the other hand, identified with masculinity when it came to personality traits, which helped her to reduce the tension between physics and her visual self. 'Girly girls,' in her opinion, do not belong in science. She was not rejecting femininity (visually) as explained in the narrative of hers above. However, she dissociated herself from the feminine personality characteristic.

> *My parents were working all the time, so I brought up myself and having to take care of myself and, you know, get myself up early in the morning and bring myself to school and then walk back, and I think, only see my parents, maybe for an hour a day. I think that gave me a lot of male kind of features if you get me.*
>
> *I feel like I have a lot of male kind of features and my motivation and my sense of humour, I feel like I am not a very girly girl and maybe that is why I fit physics so much because I am not that feminine if you understand.*

Demi described male kind of features as such: ‘taking care of oneself’, ‘getting oneself up’, ‘bringing oneself to school’ and ‘walking back’ which, I interpreted as an ‘ability to do a task independently’. Demi took a stand against the discourse of girly girls because, in her opinion, they have female-like characteristics that force them to rely on others. Gee (2000) states that individuals accept or negotiate subject positions to be recognized as being a certain kind of person. In Demi’s case, she refuses to do a certain way of femininity (doing girly) while participating in bodily femininity (dressing nice, doing make-up). She is creating her own space to express her femininity and masculinity in a variety of contexts and situations. Even though she is reinforcing the idea of ‘girls need to have masculine traits in order to be in physics’, the masculinity itself is diversified by her performing femininity visually.

***Negotiations of femininity in science***

Under this subtheme, the participants referred to the complicated relationship between the expression of femininity and being valued, respected, and recognized in science. Constructing of femininity has been a longstanding topic of interest in feminist studies. In the case of this research, it remains controversial. The term 'femininity' refers to a woman, girl, or female, which is, by definition, a vague notion. It is just as subjective to do femininity as it is to do gender. It all depends on how you describe a woman from a certain period and culture.

It is mostly related to physical appearance rather than feminine behaviors under this theme. Dressing up and applying make-up, in particular, were frequently invoked as ‘feminine' occupations.

Shalini (MSc) commented

> *I love dressing up and I am not going to stop this ever in my life, People think that just because I am dressing up or just, you know, I have a lipstick on my lips that means that I am more interested into fashion rather than my focus on science, which is not true. It makes me feel good.*

Before making the above statement, Shalini was discussing how difficult it can be for a woman to convince others of her scientific abilities. She added that people have a judgment about you when you care about your appearance. She is emphasizing that her performances of femininity orienting around wearing make-up and dressing up cannot be interpreted as evidence as a lack of interest in science.

Lou (postdoc) backed up Shalini’s criticism regarding people’s attitude towards the relationship between femininity and science. In Lou's narrative, 'femininity' is presented as a barrier to women in her field identifying with science. She suggested:

> *If you are too feminine then it is also a problem. Like people would not take you seriously, at least in my field.*

She exemplified the narrative above with one of her experience:

> *I would usually dress in jeans, T-shirts, hiking boots, and stuff like that on the field trips. If I wear a dress or skirt, I would get comments each time as being too feminine. Once one of the researchers joked that I could go and work in the streets. He was not even a sexist person. It is like a balance to find and it is actually super annoying to have to spend energy on thinking about that*

Wearing jeans, a T-shirt, and boots instead of skirt and clothes would be more practical and convenient for people who work in the field. That is the dress code, which is either masculine or neutral. As Lou explained, wearing skirts or dresses is a common way to replace naturalness or masculinity with femininity. As Lou's story above shows, if a woman doing science shows up in a more feminine outfit, her appearance is often remarked on. Perhaps it is because she doesn't appear to be a serious scientist.

Kathryn (Ph.D.) also explained that dressing more feminine in conferences would make her feel out of place. She said she was avoiding wearing ‘too girly of clothing’. Her phrase ‘you have to dress professionally’ includes criticism towards people’s attitudes to dress code in scientific conferences. Wearing girly clothes are considered to be not ‘professional’ which, for Kathryn, put women who want to be more feminine in a dilemma: being respected by others as a scientist by wearing more ‘professional’ clothes, in other words, more masculine or neutral outfits, or being who you are and still be respected as a scientist.

> *I think the world of science reflects society. I mean, when we go to a conference, we have to dress professionally. I feel like I should not wear too girly of clothing, especially for something like conferences, which is silly because it is equally professional to be a girl and I think that is kind of a weird thing as well. When you are in an environment surrounded by so many men, it is hard to know how to be a woman in that environment and still be respected. Would they still respect me if I was wearing a lot of makeup, would they still respect me if I was wearing loads of fancy dresses? I don't know.*

Diane (BA) commented that as a woman you sometimes make sacrifices from your femininity in a scientific environment such as labs. She described lab a kind of male space in which you could be alienated if you perform femininity. For example, Diana thinks their clothes in the lab are masculine rather than neutral. She explained how people appear in the labs: their skin is covered, their hair is clipped, and they wear some shoes that appear to be masculine. Diana believes it is necessary for the safety of those working in the lab, which contains many chemicals and lasers. On the other hand, it is a natural dress code for most men in their daily life. That is why Diana coded it as ‘masculine’ in her head. When she dresses like that she looks like men or more genderless. She described it as a kind of compromise she makes to fit into the lab's set-ups. She commented:

> *I sort of in some way I enjoy that I am a woman and a scientist. That is a strange combination because I like showing that it is possible and then I can be good at both, but occasionally you do have to make sacrifices like for one or the other. Like, I don't know, in labs you have to dress in a certain way when you are working with chemicals or lasers, things you have to have all of your skin covered and your hair off and your proper shoes and things. And it is just a more masculine look. And maybe like you would get laughed out of it a little bit if you tried to start a conversation about clothes or hairstyles or something that's just not a conversation you have in that context because it is quite male space.*

It is interesting to note that Diana sees her science and gender identity as a strange combination. Her phrase ‘I like showing that it is possible, and I can be good at both’ shows that she is challenging *the stereotypical image of the scientist* in people’s heads. What she told about traditional (stereotypical) feminine kind of conversation such as clothes and hairstyles in the lab as something excluded or mocked as it is quite a masculine space.  What Kathryn said earlier above “*when you are in an environment surrounded by so many men, it is hard to know how to be a woman in that environment and still be respected”* is reflected by Diane through her own experience in the lab.

Some of the participants perceive femininity as a set of roles attributed to women. They stated that the burden of traditional feminine roles crashes with women’s science career. Interestingly, although they see the traditional women’s roles as a burden for women, they also consider the roles as something which makes women stronger and multitasking compared to their male counterparts.

In the following excerpt, Jill (Ph.D.) refers to the ‘hormones, emotions, and family responsibilities’ as a sign of what women are coping with. That the women are naturally more unstable with their emotions was expressed by some of the participants just randomly at the time of the interview. Some of these narratives were mentioned in previous themes. Other narratives regarding women’s emotionality did not even reflect the participants' own perspectives. Rather, they were criticizing the way society portrays women as being more emotional.

However, Jill's statement is different because it reflects her own views on women and how she feels about them. She described it as something impossible to control and manage:

> *I think it is hard to be a woman. You have to consider so many things, like regarding your career, when will you want to start a family and how are you going to be too old for that. And how would you control your emotions and your hormones when sometimes it is so difficult, and so I think it is harder than being a man, in my opinion. They don't have to care about those things.*

Neha (Ph.D.), like Jill, associated femininity with emotions and traditional women's roles; however, unlike Jill, Neha views emotion as a kind of superiority for women that allows them to handle multiple tasks at once. As a result, she referred to women who take on traditional roles while also progressing in their scientific careers as being 'emotionally stronger.'

> *I think women are much stronger emotionally because, for men, they don't need to care about their home. Like I am married, so I have to think about home and what my husband eats for dinner and I have to work at the lab, but men don't need to think like that. So, I think in those cases all women are multitasking and stronger than men. (Neha, Ph.D.)*

While Jill links emotion with hormones and unstable feelings which in the end makes her life harder, Neha associates it with mental strength in case of dealing with double duties at the same time which in the end makes her feel stronger compared to men.

Similarly, Samiya (Ph.D.) stated women's traditional gender-specific responsibilities at home affect their progression in a science career. In Samiya's narrative, different identities intersect and create tension between one another. One of them is science identity which is related to career, the other identities are 'wife', 'sister', 'mother' which is more related to the home. It is clear from Samiya's talk that these are constructed as contradictory identities for women: 'science' identity in one hand; 'wife', 'sister', and 'mother' identities in another hand. In her narrative, I get the impression that she is criticizing rather than adapting to traditional roles. I interpreted her statement 'even if women are trying to balance it, they have still more responsibility at home' as women are now taking control of their work/life balance, but they are not there yet.

> *You have lots of responsibilities and all the time you have to prove yourself. We are progressing in our science career, but we still have a role as a wife, a sister, a mother in the house. Now even if they are trying to balance it, women still have more responsibility at home than men. Men just worry about their work. But women worry about their work and their home as well. (Neha)*

Shalini (MSc) identified herself as 'proud to be a woman' and 'really into science' when she was talking about her science and gender identities. When I asked what is special to be proud of, she said:

> *To be woman itself gives you a lot of motivation behind because you cannot deny the fact that the life of women is quite actually very much struggling and different from the life of men. It is like you do not have just one but a hundred things to focus on at one point. It is very, very difficult sometimes.*

When referring to women Shalini's particular emphasis is on being 'multitasking' and 'self-motivated'. Just like Neha, Shalini also thinks that dealing with different tasks at one time is empowering for women although it can be very difficult. Her science identity is inspired by her recognition as a woman with a reference to multitasking.

**Section summary**

This section seeks to answer the first research question "*How do female students and early career researchers in physics and physical science in higher education fields construct their science identity related to their gender identity?"* by analysing through under three key themes that emerged from the data: sense of belonging to science, doing science and doing gender.

The women's individual and community attachment to science was examined under the theme Sense of belonging to science. Regardless of their age, academic discipline, or level of study, all of the participants expressed a strong interest and enthusiasm for science. Their interest was stimulated by their curiosity, a feeling of achievement, a feeling of enjoyment, mathematics, and science competence from a young age. Regardless of their academic disciplines they all associated physical science (especially physics) with mathematics. Their interest in mathematics from their early years at school prompted them to study physical science-related disciplines at college. The women interviewed expressed a strong emotional connection to science.

The majority described science as a team effort and stated that feeling of valued, recognized and acceptance is important for their sense of belonging to a scientific community. There are differences among the participants based on their other social identities in terms of being equally valued and recognized within a scientific community. The participants who were the most ethnically and religiously diverse in the sciences were the ones who were most likely to be overlooked by their scientific peers. Despite the discouragement they feel as a result of their ethnic and religious identities, they maintained their interest in science.

Under the theme of *doing science*, how women perform science, how they view a scientist, and how they view themselves as a scientist were analysed.

Most participants complained about 'Einstein kind of white old man' stereotypical image of a scientist. Some of them distinctively separated a scientist from a physicist by assigning a physicist a male gender. The majority of participants portray a stereotypical image of a scientist based on appearance, but they rarely mention stereotypes about scientist personality characteristics, with the exception of the nerd geek stereotype. Under this theme, various personality features of scientists were identified. However, a scientist was generally depicted as 'white' and 'man' which they found boring. Some participants reported that they no longer have a stereotypical image of scientists after they were academically engaged in science. It was found that how the participants perform science is closely related to how they depict a scientist based on personality traits. For example, if their work needs multiple experiments and trials and many long hours in the lab, they depict scientists as patient and dedicated. Their science identity is shaped by the scientific activities they participate in and their attitude toward science and scientists.

Under the theme of *doing gender,* various forms of gender expressions and gender identification were identified. It was revealed that gender identity is highly subjective and is influenced by social interactions, personal experiences, a person's feelings, traditional expectations, physical appearance, anatomy, and social roles and norms, among other factors. It is complicated in and of itself. As Annie said, "*it is all in your head".* Thus, the experiences, attitudes, and expressions of women under this theme are varied. Some of the participants explained their gender identity through hormones and set of roles, some of them linked it with their science identity and reported that a 'strong woman' identity reinforced their science identity. Some of them reported women as multitasking which gives them an advantage in science. Some participants said that their perception of gender has changed after they were involved in science. Some participants perform femininity visually but reject feminine personality traits. Some do masculinity and femininity at the same time in a certain context. In short, even if they all self-identified as women, the perception of womanhood varies depending on their individual experiences, feelings, and their beliefs around gender-specific roles.

### 5.4.2 Section II: Research Question II

The research question that guided the analysis and presentation of findings in this section was:

***What are the challenges faced by them arising out of incompatibility between gender-science identity?***

**Theme IV- Struggles**

‘Struggles’ which is the main theme in this section was divided into five subthemes**:** (1) maternity and child-care, (2) low level of self-confidence and imposter syndrome, (4) anxiety of proving, (5) limited or lack of role model.

I did not prepare any interview questions regarding maternity, low self-confidence, or anxiety of proving. These subthemes were described as something difficult for the participants on their path to becoming a scientist based on their frequency of appearance in the narrative text. When I came across something challenging related to their science identity formation across their narratives, I noted down them as codes in a list. Then I categorized the codes according to the similarities among them and made up subthemes. The incompatibility of their gender and scientific identities is found to be related to the four challenges they identified: maternity and child-care, low level of self-confidence and imposter syndrome, anxiety of proving, limited or lack of role model. Then I combined them under the title of ‘struggles.’ Although the subthemes appeared in the voices of the participant, the main theme was formed as my interpretation of their challenges on the way of constructing their science identities.

As I discussed in the methodology and literature review chapters, identity is a becoming process. Becoming a science person or forming a science identity is not an isolated process. It is intertwined with people’s social identities as well as with the struggles on the way of becoming a science person.

‘Constructing a science identity’ does not mean that the participants have not identified with a science identity yet. Identities are shaped and reshaped through one’s lifetime. The word ‘constructing’ emphasizes the ‘on the move’ aspect of an identity which means that identities are on continuous development.

***Maternity and child-care***

Majority of the women who participated in this study indicated that lack of a proper maternity scheme and early career instability is one of the biggest struggles to progress a science career in academia.

According to Dee, maternity and childcare are critical issues that neither funding agencies nor institutions adequately address. She claims that they avoid the problem rather than enacting clear policies. She added:

> *For the last place I worked, I was on the gender committee. They were discussing what the maternity leave was and they said it depends on what grants you are on. They probably give you the leave, but luckily it had not been an issue yet. They had no plan. If it did happen, you would just have to ask in advance like, Oh, thinking of getting pregnant, so, could you let me know if I have maternity leave, which is just so disastrous on like all grades and no one would ever do that.*

Dee used the term 'disastrous' to describe the situation that women are in the face of such unclear maternity policies of the institutions. She added that "*when you don't have proper maternity leave and good childcare, it makes people drop out because they can just get an easier job which is not so demanding on all their time*." She emphasized the solution needs to come from the government rather than the universities.

In the interview with Dee, the emphasis was on the instability and uncertainty around a postdoctoral position. Women are encouraged to pursue careers in academic science, but once there, they are not supported.

According to Dee, not all women have children, but many people deal with children.

Regarding the tension between maternity-related struggle Carol (postdoc) commented:

> *Maternity leave depends on certain fellowships. There is some maternity leave but only for six months and that will go against your time for research because you are stopping six months and sometimes six months can be a lot. Meaning that you cannot publish something. I see friends having kids during their postdoc and they are really struggling with having the time to do the research and having the time to dedicate to the baby. I think you really have to make a decision there.*

Aine (Ph.D.) shared a similar viewpoint in terms of ambiguous maternity leave policies of the institutions at the higher education level. She expressed:

> *Because there is no rule around maternity leave, people can get taken advantage of... or you know, your position might be gone or maybe you might have your position, but by the time you come back, science has moved on so much that it is hard to catch up and, and I think, yeah, that that would be something genuinely thought I would think about going forward.*

For Aine, the uncertainty around maternity-related issues at the postdoctoral level creates a big barrier for women's progression in academic science.

> *It is after the Ph.D. level that the majority of women in science just drop off massively. And I think that is because women are thinking, well what if I want to have a family and if you have a postdoc position, are you going to get maternity leave or are you going to be able to take time off? Are you going to take a year off? And that is really, really hard. So that is actually something that I would consider going forward. And I think it would be something that would influence my decision. (Aine, Ph.D.)*

Carol and Aine's inferred meanings of the word "decision" suggest that women have to choose between career and family, while men do not. Amada (postdoc) indicated that she relies her decisions on her child's needs based on her own experiences as a mother. Her statement 'if I was single with no child, it would be much easier' suggests that she constituted her 'mother' identity in contrast with her 'science' identity which in other words, can be interpreted as 'motherhood' overshadows 'science'. The dialogue between Amada and me are as follows:

> *A: If you take care of your family, if you have a child at home, if you have other responsibilities at home, the number of journals that you publish goes down. That's one main thing that I feel. You always have to make your decision based on your child.*
> *Me: Do you think you are working harder than your colleagues?*

*A: Yeah. I have to do twice work. I have to go home, teach my son, cook, and do all the household chores and come back here early in the morning. If I was single with no child, it would be much easier.*

I met Neha (Ph.D.) in the middle of my interview process. She was in her final year of Ph.D. in the School of Physics. She told me she wants to pursue a career in academia, but she was not sure yet because research comes with a lot of pressure, including a lot of 'mental stress.'

Throughout our conversation, she frequently used the word 'pressure,' which she associated with motherhood. Maternity leave, she believes, is a significant research gap that prevents women from publishing papers and, as a result, harms their academic careers. She commented:

*Me: Do you want to progress in academia?*
*N: I am not really sure, because of all the stress of the work, I am really confused like if I go for a postdoc or maybe I just start in a company or management. So, the next step is not really very clear to me in that situation.*
*Me: Would the idea of maternity be affecting that decision?*
*N: Yes, of course, it affects me. I think, for me, it will be hard because I do research in a lab and six months of maternity leave is a huge gap. And, even for a postdoc, there is pressure to publish the paper and everything is pressure. I don't think you can enjoy motherhood like that.*

Ale (Ph.D.) stated that maternity leave and related issues 'scare' her, but it would not prevent her from pursuing her science career. Her construction of a science identity, like that of the majority of the other participants, collides with her gender identity because parental leave and childcare still fall disproportionately on women's shoulders, causing tension between gender and science identities in this study. Ale's comments are as follows:

*I know a lot of people who have said to our faces outside that I would never hire a woman in science because what if you get pregnant and really stupid conversations. We were talking about getting maternity leave and stuff like that. Yeah, it does kind of scare me a little bit. I know it is possible but it is going to be hard, but I would not be pushed.*

Diane (BA) stressed the importance of age, parenthood responsibilities, and gender in scientific career advancement. "The majority of the workload tends to fall on the women," she said. Diane's perception of women in science who have children is influenced by women (female professors) who have successfully balanced work and family life. The tension between the identities of ‘scientist’ and ‘woman’ can be combined in this way to promote positive science identity development.. In Diane’s words:

> *I have spoken to female professors about how they balance like their work-life with their family life because the majority of the workload of having children or that responsibility to take time off work tends to fall on the woman. And so that can affect your career progression. And if you take time off work are people gonna be less likely to hire me if I am about thirty because I think I am going to have kids. That sort of thing is a factor to be considered. And particularly seeing women who have done well and had kids is really nice.*

Among the participants, there was a general acknowledgment that parenthood and maternity are one of the most visible gendered issues in women’s full participation and progression in science career in higher education as academic science itself is unstable especially for first stage researchers. Carol, Dee, Lou (postdoc), and Jill. (Ph.D.) commented on the challenging nature of having a child, instability of early-career researchers, and commitment of their time to work.

> *I think a woman has to decide not to have a family. I think this is the first thing that pops up through your mind if you really want to pursue a very high level of position because you need to have dedicated time. So, it is always easier for men (Carol)*

> *I am not too much in a hurry, but definitely I am postponing having kids because I am afraid that it would impact my career and that I would rather if I had the opportunity to wait to have a permanent position before having a kid. (Lou)*

> *As you hit a certain age and you either make a decision of like, well I can have children and different job and everything will be a lot easier because*

> *you have no certainty like that you'll have a permanent position, you know, possibly at the time when you want to have children (Dee)*

> *That is the thing that annoys me the most about academia because we are not stable in our lives yet. I mean if you have got a post-doc position, you will have to move somewhere else maybe. And, it is for one or two years. So, it is not really physical to get a break from postdoc for maternity leave or whatever. So especially because I am a little bit old and I am going to finish my Ph.D. when I am 30. If I wait until I finish my Ph.D. and then I finish the postdoc and whatever to start a family and everything, I am going to be old for that. Probably not too old, but older than I would want to. (Jill)*

Carol's use of the phrase ‘it is always easier for men’ demonstrates how gender roles continue to shape society's perception of parenthood. Mia (postdoc), who had recently returned to work after maternity leave, expressed similar concerns about having a child and the gender roles that come with it. I asked her if her husband was willing to take parental leave to take care of the baby.

> *Me: Can he have any paternity leave?*
> *Mia: Even if he could have, I don’t think he would take it. He is so involved, and I mean he won't be able really to take extended periods away*
> *Me: Do you think you sacrificed from your work…*
> *Mia: Yeah. It is also, in a way, it is natural. I mean I don't think it was a sacrifice. I mean, it is just the way it's supposed to be. I mean it is good if he could help, occasionally, but I would not swap with him in the care of...*

Caring is still regarded as a mother’s job. Biological and social perception of motherhood is at the core of the feminist movement since it emerged. The relationship between motherhood and nature has been historically, politically, socially, and philosophically constructed (Okin, 1979) When motherhood is framed as nature, “the care work done by mothers and rearing of children appears as women’s responsibility” (Neyer & Bernandi, 2011, p. 165). Instead of interdependence and mutual experience, the building of motherhood in the scripts above between me and Mia shows that we think of motherhood from a female-specific viewpoint. She explained it with nature, while I related it to sacrifice. Even if Mia depicted motherhood as a natural and essentialist normative role, she explained the stereotypical view that 'men are better at science' from a social perspective of motherhood and maternity, not from an essentialist perspective.

> *Maybe I have also accepted some of those stereotypes that men are better at science. And I really attribute it now from my perspective to great extents to maternity-related issues. But no, I accept that.*

Annie (BA) was one of the youngest of all the women I interviewed. She was eighteen at the time of the interview. She also highlighted the gender roles that come with being a parent.

> *If you are doing research especially like many hours spent outside the home, and yeah having a child is like a limitation for women, whereas if it was a man, they just let their wife take the responsibility.*

Her use of the word 'limitation' for women corresponds to Carol's use of the term 'dedicated time.' Both of them define motherhood as devoting the majority of a woman's time to her children, which, unlike men, distracts her focus away from her studies. Roda (BA) like Ana pointed to the gendered roles of parenthood and its influence on working science women. She explained that the social roles of motherhood and scientist may overlap at times and leads to a sort of 'barrier' for women. The balance between simultaneous management of motherhood and scientist roles is explained in the following interview excerpt from Roda's perspective.

> *It is actually quite funny cause I know like a lot of my friends, who don't just study science but who study a lot of other things in university who are girls constantly have conversations about Oh my God I am going to study very hard for fifteen years, got a really good job, but then going to have kids, I am just not going to work because even if you have maternity leave like you're still gonna have a one-year-old, a two-year-old, a three-year-old. I never hear male friends talking about that ever. Like they never seem to ever think that that will have to be a barrier to them succeeding. But I think women cost anything like I am the same. Like I probably will want to have kids at some stage in my life and probably will really struggle to*

> *balance being at home with them and like also them wanting to be like a really good scientist or something. And I don't think it is something that men considered. It could be because women are more maternal. That could actually be a nature thing as opposed to nurture.*

Roda believes that being a "good scientist" necessitates a strong commitment to science, as Carol (postdoc) explained in the narrative above. The conflict between wanting to stay at home with the kids while still wanting to be a good scientist demonstrates the difficulty that women face when balancing family and work (science). Roda's concern here is the gender-based segregation in parenthood, which appears to be influencing the career plans of women who want to advance. She commented:

> *While I think definitely like 20-year old lads are not thinking about 15 years-time when they have kids. That is like the last thing for them. But I think it just forces women to be a lot more realistic and not be able to like a dream as much, which I don't think is a good thing.*

I would like to draw attention to quoted sentences of Roda's: 'women cost anything', 'struggle balancing being at home with kids and becoming a good scientist', 'women are more maternal', 'it forces women to be more realistic and to less dream'. According to her, women have a maternal instinct as a result of their gender's natural or social construction, which limits their ability to dream of becoming a good scientist. If they have children, it is a struggle for them, which is not good. It is an anticipated struggle, though, because it's a problem that women have always had to deal with; in other words, women, as Roda put it, 'cost everything.'

When I asked Julianne (Ph.D.) what it's like to be a woman in a scientific environment, she also mentioned the gendered view of parenting. She asserted:

> *So far, it has been good. I think the future will be less good in terms of like, if I want children it is me who takes responsibility for it. So, I cannot be in academia cause if I have like a three -year contract, I cannot have children.*

As can be seen narrative above, that being a woman and a mother have more in common than being a woman and a scientist working in academia. Much of the conflict Julianne outlined here stems from the fact that women are still viewed as the primary caregivers. Julianne's expression shows that women take responsibility if they decide to have a child and they need stability for this. Besides, academia does not provide it, so 'she cannot be in academia'. Here, the constitution of motherhood overlaps with the constitution of a scientist who wants to progress in academic science.

Reese (BA) established a connection between physics, academia, and motherhood within the context of stability. She said that neither physics nor academia is a stable path for women if they want a child. Reese, like the other participants, discussed the time frame in which women would want to start a family and have children. Her emphasis on the 'lack of stability' in academia and physics, as well as the 'need for stability' when a woman becomes a mother, demonstrates that mother academics in physics are treated differently than father academics in physics.

> *Like physics is not very stable, or academia is not a very stable path. I went to a Women in STEM talk a few years ago and they were talking about why women ended up more in industry and men in academia. I think you get like five-year contracts with academia for academic research. Sometimes you have to move around for that and if you are a woman, you know, you have a time-span with when you can have a family and have kids. So while a man could either wait a bit longer or you know, he can provide money in whatever way, but he doesn't need to provide his body to do that, then he has a little bit more flexibility in terms of like moving around. If you are planning on having a child or anything like that, you need a little bit more stability than that.*

The argument here shows that cultural belief about gender plays a significant role for women and men in the choice of an academic science career. It is not what Reese has experienced, but what she has seen in a Women in a Stem Talk group and, most likely, in the physics world around her.

The repeated use of 'stability' by the participants and the emphasis of motherhood shows that motherhood becomes a defining factor in their assumed identities in academia. Cuca (BA) also brought up the issue of academic science career insecurity.

> *I don't think there is a lot of sustainability in academic careers. I think there are lots of four-year contracts and then you are left looking for another job. I don't know. I am not interested in that instability. I can see all the different disparities between men and women, but I don't want that to be a defining factor in my life. I know probably it will be like if I decided to have kids that would probably affect my career. That really annoys me. But I like to put that in a box.*

Cuca is annoyed by the fact that if she wants to have children, it may affect her career because, as a woman, she is expected to shoulder more responsibilities. She is aware that men and women are assigned different gender roles, which frustrates her. As a result, she prefers to dismiss it and store it in a box.

Through Mia's (postdoc) experience below I tried to explain what is in the 'box':

> *Last year, my real kind of significant experience of trying to secure funding…Actually, I felt that I was rejected based on to a great extent, really my CV, I mean, it appeared not as independent, but it was worse than that because one of the referees kind of explicitly, mentioned the fact that, I have had two maternity leaves, but that cannot account for the kind of my metrics which don't match with my colleagues from the same generation. I mean, after with that many year's postdocs and Ph.D., that is a bit, yeah, a bit extreme for me like that, that he pointed out kind of try to measure really mean what maternity leaves can account for in terms of citation. He was saying, Oh, look at that guy, he has almost 10 times the amount of your citations. I mean, you cannot explain this by maternity leave and, yeah, I guess I do. I mean, they don't affect equally men and women…. you cannot give the same credit for men and women who have children. I mean it is not the same thing.*

Mia was disappointed to hear one of her referees compare her to a male academic from the same generation with ten times the number of citations. She described it as 'extreme' after many years of commitment to science as a researcher. She linked her funding rejection to the number of citations and publications in her CV, which she believes can be explained by her maternity leave. She did not explicitly state this connection, but the number of citations and publications in her CV hinted at it. She believes that since male colleagues are not equally affected by parental leave, they have a greater chance of being hired/obtaining funding.

***Low Level of self-confidence and imposter syndrome***

During the interviews, the participants brought up the issues of self-confidence and imposter syndrome that had arisen from the data analysis. Regardless of their level of study, they reported that men within their academic community have more self-confidence in their academic (scientific) skills than women. Imposter syndrome was only experienced by some PhDs and postdoctoral researchers. The participants pursuing master's or bachelor's degree did not report any imposter syndrome experienced. Direct personal questions about self-confidence were not asked of the participants. It did, however, appear regularly in their narratives.

Even though girls are highly competent, they have a low opinion of their science ability, which leads to lower participation in class and appears to be a lack of confidence in their abilities, as Annie (BA) pointed out below.

> *I do think that males are more confident in their abilities. I feel like they are all super confident in their abilities probably because they have always been good at mathematics and they have always been told how good they are, and now they have like this idea of themselves. Whereas I have talked to this with my female partners in class, and we are a little more like I don't know I feel like we are not proud of our achievements even if we are good at science, or we are not this confident in general in our abilities as our male classmates.*

In the narrative above, I interpret that ‘being good at science’ is not an indicator for Annie and her friends to develop confidence in their scientific abilities. In her classroom, she has noticed that girls have a more pessimistic attitude toward their accomplishments and talents, while boys are ‘super’ confident in their abilities. Annie attributed it to the traditional gendered expectations of boys and girls in terms of academic abilities in schools." They have always been told how good they are," she says, "and now they like this idea of themselves." shows that traditional gender stereotypes and the belief that boys are better at mathematics and science contribute to self-confidence. Confidence, according to Annie, stems from people's perceptions of themselves in society rather than their own perceptions of themselves.

A similar viewpoint was reported by Lou (postdoc). She coped with low self-confidence until she finished her Ph.D. She said that during her undergraduate years she felt shy and did not participate much just like other girls in the class. After she finished her undergraduate and gained some work experience she was attracted to academia, but she was scared of not being competent enough. She commented:

> *At the very beginning when I finished my undergraduate school, I started to work as an engineer then, I was attracted to science in academia. I think at first, I was scared that I was not good enough for it. I thought I had to be more focused, maybe more, I don't know, more intelligent, more brilliant. I think I was afraid that I was not intelligent enough before starting, but I did a Ph.D. and I am glad I did, but I am still fighting with the imposter syndrome.*

Lou’s lack of confidence was based on her perception of herself as not ‘intelligent’, ‘focused, and ‘brilliant’ enough to do a Ph.D. She said she was scared of not ‘being good enough’. Lou said that from her early school years she was always good at science and mathematics. Her feeling of anxiety before a Ph.D. was not related to her real academic abilities. Instead, it was the result of her own low self-esteem regarding her academic skills. When I asked why she had a confidence issue as a successful student, she responded:

*I think part of it is, the education because maybe as a female I was not raised to be as confident. At least I can see some other, male researchers are more confident or they fake it better, I don't know. I would maybe lose much more energy in thinking that I am not strong enough. So, part of it is, yeah, maybe self- perceptions. But part of it is really external. It is from society.*

Lou's use of the terms ‘self-perception,’ ‘part of it is external,’ and ‘it is from society’ corresponds to Annie's mention of gender stereotypes in regards to girls' and boys' qualifications and skills.

Reese’s (BA) viewpoint is different in the sense of women’s self-perception of their academic abilities. She said that girls are more perfectionist compared to boys in terms of their academic abilities. Girls can be more judgemental towards their own abilities which may result in dropping out of the course. Reese commented:

*The girls in my class who did physics did really well in physics, and the ones who did applied mathematics also did really well in applied mathematics. Some of my friends who were doing undergrad physics as well say that when girls are performing okay, or not so great in physics, they are very likely to drop out and be like, I will do something else. Whereas a boy at that same level is not questioning whether he should or should not be there. And it is not a conscious decision. It is not like I am a girl so I should not be here.*

I would like to call attention to Reese's use of the phrase ‘conscious decision.’ Reese compared men and women/boys and girls in terms of self-confidence and scientific skills, just like the other participants. Reese was studying undergraduate in theoretical physics at the time of the interview. Dropping the course was expressed mostly by undergraduate students during the interviews.

I noticed that Ph.D. or postdoc participants who had or heard of low confidence issues from friends mentioned a career change from academia to industry, while undergrads mostly talked about dropping the course when they had a low confidence problem. People with a Ph.D. or postdoctoral degree have more invested in their scientific careers, so they prefer not to abandon it completely. However, it may be easier to change courses or careers entirely at the undergraduate level, particularly early on.

Returning to Reese's comments on the unintentional decision to drop out of physics, she stated that there are some discrepancies between boys and girls when performing physics. It is interesting that ‘at the same level boys do not question whether he should be there or not’, while girls drop out and do something else. This statement is consistent with Aine's and Lou's narratives in that perceived self-confidence in scientific ability and skills may be linked to gender stereotyping. As science has long been associated with a certain gender category it would be challenging for individuals who do not identify with that gender. So, that may result in a conflict between gender and professional identity. In the cases of Reese, Aine, and Lou, it is clear that gendered and stereotyped beliefs that science belongs primarily to men have an impact on the level of self-confidence of women scientists.

April (MSc) claimed that her friends in her undergraduate years also struggled with low confidence. The reason for this may be that it is people's first encounter with academic science, and it has a negative impact on their confidence. One of the participants shared her personal experience of feeling the worst of the class in her first two years of college, despite being the smartest in the class in high school. The reasons for this may vary, but my impression from the interviews is that this is the first time the girls have been engaged in a male-dominated environment, as high schools in Ireland can be single-sex. They may feel like outcasts in physical sciences disciplines when they arrive at college because of their gender identity. She mentioned in April that boys and girls have different attitudes toward their self-confidence in their (academic) scientific abilities.

> *I had this conversation with people in my undergraduate degree and it is like the boys don't really question that they are there, you know, if something is tough, they will be like, oh, it is hard. But then the girls kind of feel like.. we feel like we maybe should not be there, so we try even harder*

*if there is a kind of maybe a kind of needing to prove that you can be there. The boys don't think, Oh God I should not be here. This is not the right place. I am not smart enough. But I know a lot of the girls in my undergrad would have had those exact thoughts. I just know that the girls, there was the only kind of one girl that was kind of confidence in her ability and reason to be there. The rest of us were kind of a bit more like God I cannot do this and that.*

The phrases ‘I am not smart enough’, ‘we should not be there’, ’I cannot do this’ illustrate that gender stereotyping causes, girls, to question their own abilities in science. April claimed that only one of her friends believed in her abilities and reason for being there.

This reminded me of my conversation with Dora (BA). During the interview, she often expressed her confidence and strength as a woman studying physics. The conversation went as follows:

*Dora: Anytime I tell someone I do physics, there is always just like, really?? It happens everywhere. if you are at a bar and someone asks you what you do and you say physics, they are very stoned.*

*Me: They don't expect girls doing physics or they don't expect you to be a physicist?*

*Dora: I think both. I think it comes hand in hand. I think maybe how I look and how I present myself and how competent I am. I found a lot of girls in physics not that confident.*

*I find like men, maybe it is a false sense of confidence, but they are more confident than women by average, at least in my class.*

Dora’s narrative illustrates that women’s self-confidence and competence, as well as their physical appearance (feminine look, in Dora’s case) are situated outside of physics from the perspective of others. Dora said that she has a challenging personality which gives her motivation for her persistence in physics. It seems that Dora’s physicist and female identity raises her self-confidence in her scientific skills as femininity and physics are considered to conflict (that is based on what Dora experienced with people) from people’s perspective. Her self-confidence appears to be growing as she confronts the conflict.

Cuca, Diane, Joan, and Roda (BA) evaluated low self-confidence issues through their observation of boys and girls in their classes.

> *Boys are more confident in their own answers. They are like I really know the answer, or they are just more confident than girls. Maybe more encouraged to speak up and stuff (Cuca, BA)*
>
> *I think the girls definitely have a lot less confidence even though a lot of them can be often like a lot better than the lads. But the lads often seem they know more. I think they probably have a bit of an idea that they feel as if they more deserve a kind of place than other people. Physics is like pretty male-dominated We still haven't had a female lecture, like every lecture that I have ever had in physics, maths, or applied Mathematics as being a man. (Roda, BA)*
>
> *I teach maths grinds for high school students now and I notice a big difference in confidence between the girls and the boys just at the few people that I have. And even with my friends, the boys are more confident in general. They are more confident that they can do the maths and it will be fine. But the girls express their worries more, I think. The reason may be a physic is more difficult. Even if the boys are having trouble with, they are less likely to ask someone else for help. If they do start struggling in a class or something, they maybe don't want to admit it or show it. (Diane, BA)*
>
> *Girls, in general, are probably determined or driven maybe, kind of wanting to be better. I feel like if one of the girls failed, they would be working so hard and probably think like, oh, I am not good enough, I am going to drop out. Whereas I think loads of the guys say, Oh I failed a few exams and they don't care. (Joan, BA)*

Cuca explained that boys tend to talk more than girls in the class because they are more confident in themselves and more 'encouraged to speak up'. Diane emphasized that physics is difficult. I have heard it from other participants as well. Diane remarked that even if boys struggle in the class they do not want to admit it. However, she said that girls express their worries more. From Diane's observation it is clear that even if girls are competent in mathematics and physics, they develop lower confidence compared to boys in the class because of the fear of failure. Roda also expressed that in her class ‘a lot of girls are a lot better than the lads’, but they have ‘a lot less confidence’. She attributed it to the fact that physics is viewed to be a predominantly male discipline and boys have an idea that they fit in it more. Joan also used the words ‘determined’ and ‘driven’ to describe the general characteristics of girls in the context of science, but in the face of failure she described girls’ attitudes as such: ‘I am not good enough’ and ‘I am going to drop out’. It is clear from Joan’s narrative that girls may be self-critical of their abilities whereas boys can be self-hopeful.

Similarly, Ale (Ph.D.) compared men and women in her academic discipline in terms of confidence. Just like Diane, Ale also expressed that women are more afraid of failure which, I think, drives them to be a perfectionist at their works. Ale herself is a very passionate, dedicated, and success-oriented researcher, as to my impression of the interview. She commented:

> *Men tend to be much more confident than women. Women overthink everything. The women I have been working with or just friends of mine who working in a similar field think that our work has to be perfect. We put extra stress on ourselves if it is not perfect, I am not happy. Everybody who I know who's successful as a researcher has this pressure on them. Men do in a way, but definitely not as much. If something doesn't work, oh, it doesn't work. They are like if I have made a mistake, I will deal with it tomorrow. But we would feel really bad if something was our fault.*

Her statement ‘if it is not perfect, I am not happy’ illustrates that she tends to be very critical of herself or her abilities as a scientist. I am not sure if this is related to her gender or her personality based on this statement. Her other comments, on the other hand, generalize women in her academic discipline as being inclined to anxiety and stress in the event that something goes wrong. Without mentioning a researcher's gender, she stated that “all successful researchers have this pressure on them." However, she distinguishes female researchers from male researchers in terms of dealing with stressful situations when it comes to the emotional sign of stress. Women, she believes, would 'feel really bad' while men would be ignorant. It is also mirrored in Kathryn's narrative, which follows:

> *I am very hard on myself. I feel like I have to work very hard anyway, but I don't know if it is because I am a girl, or it is maybe my personality. I think that boys often have a very big degree of confidence just in them. Whereas I don't want to phrase this but even if they sometimes do like shit, they still seem very confident in what they are doing.*

Through the analysis of the participants' narratives, I realised that when it came to the issue of confidence, they frequently compared boys and girls in their classes or academic circles, and they blamed low confidence on differences in attitudes between boys and girls toward their skills in science, mathematics, and physics. The majority of participants, including Kathryn, expressed that they worked harder than their male friends. Some attributed it to the difficulty of overcoming gender stereotypes, while others were unsure whether it was due to their personality or gender identity. One of them was Kathryn. However, her phrase, 'even if boys sometimes do shit, they seem very confident in what they're doing,' gave me the impression that she is working hard to avoid making a mistake or doing 'shit' like men do (from her perspective).

Julianne explained to me that girls' lack of confidence in their mathematics and physics skills begins in elementary school.

> *In my school, a lot of people were really good at mathematics, but they never considered doing mathematics or physics because I think it might be like to do with confidence or something where they just see like boys do it and boys' kind of act like they are better even if they are not. So, I think girls are kind of intimidated out of it.*

Girls' ability to do well in mathematics does not always lead to a sense of competence in mathematics and physics, as Julianne's talks demonstrate. This, according to Julianne, may be due to girls' lack of confidence in their skills. Carlone and Johnson (2007) identified one of the aspects of science identity as competence. They described competence as knowledge and understanding of science content. From the analysis of the interviews, I have seen that the sense of competence may be affected by low self-confidence which may result in women developing a sense of anxiety towards their scientific abilities and question their capability and competence. Even if girls have full competency in their scientific knowledge, their low confidence may affect their ability to reach their full competence level. This may lead to dropping the course, a career shift, or low performance.

Julianne's lack of confidence is shown to have an impact on her science identity development in the following narrative. When I asked her how she would describe herself as a scientist, she said it had something to do with her lack of confidence. The conversation between me and Julianne went as follows:

> *Me: How would you define yourself as a scientist?*
> *J: I usually have low confidence, so when I do exams, I always think I did worse than I actually did.*
> *Me: Why do you think you have low confidence?*
> *J: I don't know. I think it is a real thing called imposter syndrome. I think like the majority of women in academia experience it. I guess like everyone around me always acts like they know everything that is going on. When I feel like there is something, I am not sure about, that kind of worries me.*

It is seen that Julianne's science identity has been affected by a false assumption that she knows not much while everyone else 'knows everything that is going on'. She called it 'imposter syndrome'. The study which focused on mindset, gender bias, and confidence (Hill et. al., 2017) indicates that science confidence has significant associations with having a science possible-self and the desire to be a scientist. In the cases of Julianne and other participants who suffer from low confidence and imposter syndrome I have noticed that one's desire to be a scientist is the first and main step to go into science, but this desire may sometimes be diminished as a result of low confidence and imposter syndrome which may negatively affect person's self-identification as a scientist.

Lara (Ph.D.) said that in the first and second year of her bachelor's degree, her science confidence was really low, but she did not give up because she was more interested in physics than any other subject. Her desire and her interest stimulated her to continue in physics.

> *The first and second year of my bachelor's degree it was a real hit to the confidence. I was not used to doing badly in exams. I just felt like I was the worst in the class. Looking back, I very much was not. I was actually in the upper half, but you don't realize that the time. So, my confidence was really low, and I was like, Oh, my God, I don't think I can do physics, but at the same time it was still more interesting to me than the other options. I would not consider myself a good physicist per se, I think I am kind of battling that confidence, that imposter syndrome myself all the time. I am still working on that. But I see myself as a scientist and I see myself as a mentor and a teacher.*

Lara said that she was still struggling with low self-confidence. Just like Julianne, she linked it with imposter syndrome. The distinction between her low self-confidence of her scientific skills in her early college years and her evaluation of those years now as a Ph.D. researcher caught my attention in her narrative above. At that time, she felt she was 'the worst in the class', but now looking back those years, she said she was 'in the upper half'. Other participants' self-evaluation of their scientific skills showed the same pattern. They are so much more than they think they are. They are unable to recognize their real talents, skills, and competence due to a lack of confidence.

It is also worth noting that Lara self-identified as a'mentor,' a 'teacher,' and a 'scientist,' according to her narrative. She told me during the interview that these identities complement each other and allow her to develop a strong science identity. Lara actively participates in women in science groups.

> *My gender (feminist) identity comes into play in my I guess science identity because that leads me to do all this work with helping, you know, women get into science and feel like they should and can stay in science. That is very rewarding to me*
>
> *What drives me is that it is not just discovering new things which are like typical of anyone who would want to do science, but it is helping other*

*people and it is helping other people understand that. That is where my love of teaching and my love of mentoring comes in.*

As shown from the narrative above, mentoring and teaching positively encourage her to develop a strong science identity. This, in my opinion, is also how she deals with imposter syndrome. Mia (postdoc) stressed the sense of accomplishment in combating a 'lack of confidence.' She expressed:

*When I am feeling low and lacking confidence, I always remember my medals from my teenage years, and I say, God, I was the first and only girl in the country to win this. Come on, get yourself together.*

From Mia's and other participants' narratives, I have seen that gender plays a critical role in shaping women's science confidence both positive and negative ways. When people identify with a particular gender, they may (partially) adopt gender stereotypes As Reese said, it is usually an 'unconscious' behaviour. However, they also challenge gender stereotypes by persisting in science as who they are.

***Anxiety of proving***

The anxiety of proving emerged as a subtheme from the participants' narratives as a sign of emotional response to gender stereotypes, unconscious biases, and low confidence in a science context.

The study which examined biases and stereotypes on women's anxiety in science narrative indicates that "feelings of doubt or anxiety in STEM can arise from two sources: the difficulty of the task and fear of confirming a negative stereotype" (Freedman et. al., 2018, p. 180). The women's narrative under this subtheme is more in line with an emotional reaction to negative stereotypes.

Demi (BA) reported that she constantly had to prove herself in front of other people who did not expect her to be a physicist:

*When somebody does not expect you to study physics and then you tell them, it is like every sentence that I say afterward they will listen to it and they will try and kind of see, oh, is she really doing science, is she good at science. If they have questions about science or physics or in general, they would always look to me to see like, oh, does she know the answer?*

In the interview, Demi told me that some people hold racial and gender stereotypes about her. She gave me two reasons for that: her appearance and her name. She said that she sometimes met people in a bar, and they seemed to be surprised upon hearing that she was studying physics. Especially as ‘a blonde girl who has an Eastern European name’, when she dressed and did makeup, she experienced that people did not expect her to be a physicist. The narrative above was a follow-up conversation of her statement about the effect of her racial and gender identity on her science identity development. It is seen that her anxiety of proving is derived from people’s racialized and gendered expectations from her. The phrases ‘is she really doing science’, ‘is she good at science’, ‘does she know the answer’ are all that is reflected from people to her which results in self-defending of her place in science.

A similar experience was reported by Jill (Ph.D.), but unlike Demi, Jill expressed that “*being a woman here I do not feel uncomfortable, but the being from somewhere else that is the biggest struggle”.* That she did not feel ‘uncomfortable’ as a woman in her field may (not sure) be from the fact that she was in the chemistry research group which is more gender-balanced.

She went on as follows:

> *If you are outside of college, outside of this bubble, then you have to constantly be proving of what you are doing or doing a Ph.D., that you are a smart person and everything. The people who immediately looked down to you because you are not from here and they think less of you because of that.*

The narrative above shows that she experienced it outside of college where people do not know her educational background. In college, she still had to prove herself, but she said that it took less effort, because the college science environment is where she can present her scientific skills. As she expressed “*they are convinced by your work and they leave the stereotype behind.”* people see her science self only when she proves herself.

Some of the participants stated that when they first arrived at college, they felt the need to demonstrate their abilities. Roda (BA) explained that she did not feel that way in high school as she did not feel minority by her gender. She commented:

> *Not in secondary school because it was an all-girls school, but in university, yes. You still do sometimes feel as if you kind of has to justify your place there.*

Roda's narrative shows that she needs to justify her presence in college because as she said physics which is her academic discipline is greatly outnumbered by men. Unlike Jill who felt pressure to prove herself because of her racial background, Roda's feeling of proving stems from her minority status by gender in her class at college.

> *I went to an all-girls school, which I think really really helped because there was never like a feeling of proving myself. I think particularly when you are in secondary school, it is probably when people feel like maybe more nervous asking questions or more likely to stay away from certain subjects. But that doesn't happen in an all-girls school. I was really really lucky. Particularly my physics teacher was brilliant, relieving, and encouraging.*

She did not feel the pressure to prove her skills among girls in secondary school, as evidenced by her comparison of her secondary school and college years. Furthermore, she did not feel the need to 'justify her place' in an encouraging and supportive environment. Based on my interpretation, it was a 'safe' space for her in which she could naturally perform her science abilities.

In Diane's (BA) case, at first, her gender identity seemed to be a determinant of proving her scientific abilities in her class where her gender is not equally represented. The fact that 'there are not many girls in the class' prompted her to work hard to justify her place, just like Roda did. However, once she got used to people and became friends with them, she did not feel to prove herself anymore. Diane commented:

> *I think I did come into university with that attitude of, oh well look at around me, there are not many girls in this class. I better work extra hard to prove*

> *that I should be here, but I think I feel that now I have proven myself. I have come this far. I don't feel that competitiveness with the people in my course anymore because I know them all.*

It is seen from her narrative that at first, she felt a minority by her gender and tried to prove that as a girl she could do physics and earned the place of her pride. Then, after she knew the people in the class, she did not emphasize her minority status as a 'few girls out of many boys'. Diane stated that her stubborn personality trait inspired her to not give up and to prove to others that she was capable and qualified to do physics.

> *I knew that physics doesn't have a good reputation, but I am stubborn. I think that it didn't put me off. I was like, oh it is not for girls. Well then, I am going to do it. I am going to show them because I am contrary in some ways.*

In the quote above, it can be seen that Roda is challenging the stereotypical belief that 'physics is not for girls.' Roda, as shown in the following narrative, needs to be accepted and respected as a scientist by herself and others.

> *I don't know if that is just me challenging myself or trying to overcome expectations because I could have an idea in my head of how I want people to see me. But that could be completely different than how people actually see me.*

The participants often mentioned how they were subjected to stereotypical beliefs from others, which put them on the defensive. Then they struggle to prove their scientific abilities by working harder and conforming to their scientific position. Bias or gender stereotype beliefs are not always clear. As Julianne (Ph.D.) said "*no one is outright saying, you are a girl, you are less good. They might just think I am not good or, just kind of assume or kind of not take me as seriously."* As Julianne's statement illustrates, women have a tendency to rate themselves as less competent than they are, as in , 'I am not good.' Women who have recently become aware of gender stereotypes, on the other hand, may be motivated to challenge rather than accept them.

It is a 'subconscious' reaction to being outnumbered in physics, according to Dora.

> *It is kind of subconscious like, when I walk into a room and there are twenty boys doing physics and I am the only girl, I feel like that, you know, that is more on me. I need to make myself more known.*

Dora's challenge is an answer to both numerical and normative male dominance in physics, as seen in the preceding and following narratives. Throughout the interview, Dora stressed the importance of becoming a role model for girls who want to pursue careers in physics. She believes that the combination of being outnumbered and being negatively stereotyped can cause girls to avoid physicist. I also got the impression from our conversation that she wants to show herself and others that ‘girls can do physics’ by rejecting gender stereotypes and increasing women's representation.

> *I do feel like I have to work harder than everyone else. I feel like I need to make my presence known more. Just so people can see this is a girl in physics, I think I work ten times as hard as people around me, men around me. And that is for a lot of reasons, I can say that I academically may be better than them, and I can approach situations better than them, but that took a lot of personal work to get there.*

From the analysis, I conclude that women’s internal (emotional) pressure to prove their scientific abilities and performance may continue at a higher academic level for several reasons. Women can still need to prove themselves, at the postdoctoral level, as their age, qualifications, and experience increase. The fear of proving arose, whether it was derived from low confidence or not, when the women felt they were negatively stereotyped, according to the analysis of the interviews. It is called as gender identity threat (Van Veelen et. al. 2019). It has been stated that it emerges “when women feel judged based on their gender rather than their professional competence, or when women feel uncomfortable in work situations because of their gender, such as in relation to sexist remarks or jokes” (Van Veelen et. al. 2019, p. 2) The following narratives are in line with the argument above.

*As a woman I don't want to ask for help from somebody, I tried on my own. If they offered me help, I am okay. But sometimes it is kind of discrimination that women cannot do it. I would feel hesitant to ask for help rather than they offer me help. I don't want to show that I am weak to it. If they come forward to do it as a friend or some as a colleague, then I am happy to get some help if I need it. (Ramya, postdoc)*

*I say that there are more men than women in this field, right? So, most of the work has been done by men. The work of women has to have an impressive work. Sometimes women need to prove themselves because of all the greatest discoveries in science made by men. It is harder to be outstanding as a woman. (Carol, postdoc)*

*I think I need to prove myself more because I think there is still a bias in the way we are perceived for, not for everyone but for a lot of older researchers who are mainly male. Some of them are obviously sexists and some are not as much, but they still have a bias, I think. (Lou, postdoc)*

Women have made important contributions to science since the beginning, but their achievements have been underestimated and ignored, as I mentioned in the previous chapter. Carol pointed to both the numerical dominance of men in science as well as how often men were given credit for great discoveries. As a result, she stresses that women's work in science has to be ‘impressive,’ which means that they must work hard to show their contributions and earn the same credit as men. The feeling of proving comes from questioning the ‘discrimination that women cannot do it’ in Ramya's case. It is likely that the 'it' here applies to a task she is working on. Lou's reaction to gender inequality, which she perceives as coming from some ‘sexist’ researchers, is also proving herself in science. From Lou’s, Carol’s, and Ramya’s statements it is clear that when women feel judged based on their gender rather than their professional competence in science, their gender identity becomes salient and triggers the women to prove their scientific abilities.

***Limited or lack of female role models***

Some of the participants stated that they were influenced and encouraged by their peers, teachers, and family members to choose science at college. They did not indicate any effect of the role model's gender on their science-related attitudes or interest. The majority claimed that it was primarily their personal interest and enthusiasm that motivated them to pursue science in their early years.

However, most of them said that having a female lecturer or academic as a role model would boost their motivation and influence their future goals in college. They specifically mentioned the lack of female mentors and role models in academia. The lack of a role model was expressed by undergraduate and graduate students mostly. They expressed that the availability of 'people like me' is important to be at the early stage of their career in college as it would give them the possibility to be in their position.

The majority of the participants, who were undergraduate and graduate students at the time, stressed the importance of women's physical presence in academia. They particularly assigned a 'female' gender to the role model or mentor in a college context, on the other hand before the college, secondary school years or early years, gender identity was not often reported as a significant point to be influenced.

In the following narratives, the participants agreed on the positive impact of female role models as lecturers or professors on their career aspiration in academic science. Through analysis of their narratives, I come to an understanding that a lack of role models does not solely an indicator of leaks throughout the science pipeline. However, they reported that 'it makes them feel like it is more possible'.

Roda (BA), a second-year physics undergraduate, said she wants to be a lecturer but has been discouraged by the lack of female lecturers up to third grade. The conversation between me and Roda went on:

> *Roda: We still haven't had a female lecturer. I know there are female academics in the school, but they just happen to teach third and fourth - year modules*
>
> *Me: Does this affect your performance in the class?*

*Roda: I think knowing that they exist is an important thing to know about. I am not sure if it would affect my performance too much, but I would love to be a lecturer and I have never had a female lecturer before. It is harder for me to relate to a male lecturer than a female one because they are a different gender than me kind of. I think it is also important when people are trying to get an idea of what they want to do in the future that they can see themselves. If they can see somebody in that role and they are like, oh that person is kind of me, I want to do that. I am not seeing that until I am a third or fourth year. And a lot of people have decided if they are going to go into business after science or if they are going to continue with science and stuff like that.*

For Roda, the physical presence of woman lecturer in the physics department is important as it can be seen from her statement: 'knowing that they exist is important'. However, for Roda direct interaction with a woman lecturer in the class would benefit her more in shaping her future goals in academic science, because this way the position would not only be desirable but also achievable.

Dora (BA) told me that '*it is very important for people to see you'* As I already discussed in the previous section under the theme *Community attachment to science.* Dora emphasized her wish to be 'very active' in the physics community so that people can 'look up and see this is a girl that is done all of this'. Through the interview, she repeated how important for her to be seen and heard in physics. In the following narrative, just like Roda, Dora also expressed the importance of direct interaction with a woman lecturer or 'women in successful position' for identification with that person. She commented:

*I got to the stage where I was looking around at the academics and there was one woman who was there for years, but I never had her as a lecturer. She ended up retiring last year. I knew that there was a woman there, she has gone. That is the only woman that I saw. There is another one who just came out of postdoc, now she is head of my course and she is lecturing, she is doing a lot. She is young and she is the woman that I see now. I did not see women in successful positions before, and I found that strange.*

The presence of a female lecturer had a positive impact on Dora. She characterized her as 'young,' 'hardworking,' and 'active in the field,' all of which Dora aspires to be. Annie, a first-year physics student at the time of the interview, used terms like ‘international,’ ‘female researcher,’ and ‘successful’ to describe the ideal ‘her’ in science in the future. Annie herself is an international student in Ireland who wants to progress in academic science. The following quote shows that a positive role model would give her the possibility to picture herself in the position of that person. She expressed:

> *It is kind of empowering whenever I see like a female researcher or maybe an international female visitor being successful. It would prove to me that I could be one of them.*

Diane (BA) stated that she had only one female lecturer in three years in college. Diane's talk about being associated with someone successful and ‘well-doing’ in science echoes Annie's words.

> *It would give me confidence as it is nice to see someone that you can identify with, well-doing, succeeding in the field that you want to succeed in because it makes you feel like it is more possible.*

It is evident from Annie's and Diane's narratives that having someone in a senior role who has a similar experience and has been active in science will make it more attainable for students.

The issue of men's dominance in their academic fields was brought up by all of the participants in some way. As a result, they primarily assessed the issue of ‘role models’ from a gender perspective. Jill was talking about her wish to progress in academia. She was in the third year of Ph.D. at the time of the interview. She was closely observing the postdocs and the professors in her field. She was uncertain about progressing in academia because, in her opinion, ‘women get lost at some point’. She explained:

> *Jill: If you want to progress you do a post-doc and then become a professor, but I feel like it is more difficult for women than for men. If I see the top of where they could get, you see a lot more men than women. Women get lost some at some point in the chain.*
> *Me: How does this affect your performance or how does it affect you?*
> *Jill: It doesn't really affect my performance, but that kind of discourages me to stay in academia after I finish my Ph.D.*

In Jill's case, the fact that there are fewer women ahead of her ‘discourages' her from continuing in academia. Lara (Ph.D.) shared a similar view concerning her identification with male professors. She said:

> *It was the subconscious thing because when I saw male professors all the time, it just was not occurring to me that I could be standing in that position.*

Later in our talk, Lara explained why she could not see herself in the role of a male professor:

> *I had one or two female professors, but it was mostly men and I didn't realize how much of an effect that had on me. It was only at that Women in STEM conference that I actually thought about what my life would be like if I had their job. I was thinking stuff like if I had that job, would I like traveling as much as they have to? If I had that job, how would that work if I decided to have a family? How are they managing their family life, how do they find this job? How did they get into it? All these questions were only just occurring to me because I could finally imagine myself actually doing that.*

Lara's attendance at the 'Women in STEM' conference during her undergraduate years marked a turning point in her understanding of the visibility of female researchers and professors in her field. As can be seen from the above narrative, when Lara felt like she was in the minority because of her gender in her college physics class, she had no idea how it would impact her ability to imagine herself in the role of senior people. She felt like she might be one of them after the conference. Lara's questions to herself reveal that she saw the conference as a preview of who she might be in the future, as the women's life and work phases she encountered seemed more relevant to her. At the time of the interview, Lara was involved in outreach programs and women in science groups. She said that she wanted to be a role model for young girls.

Similarly, April (MSc) was involved in an outreach programme and went to her own secondary school. She said that students could not believe she graduated from that school and studied physics.

> *They were kind of surprised when I said I am working for satellites. I am a physicist. They are kind of like, whoa. And I am like, it is not that big of a deal. You know, it is completely possible.*

She said that she was just like them during those years. She would never have seen herself as a physicist when she was in high school. She said, "*It seems so unachievable when you are in secondary school.*" Like Lara, April also wants to show herself (her presence in physics) in the public sphere or community so that "other girls can see her in science and feel that it is more possible that they can do it."

During the interviews, Kathryn (Ph.D.) also mentioned the male dominance in physics in college, as did other participants.

> *Coming into my class was quite weird because I came from a girls' secondary school and then I came into a class where when I started there were only three other girls. Also, most of our lecturers were men.*

When I asked Kathryn if it affected her performance in the class she responded:

> *I think it would affect my performance. I think the fact that there were female physicists, but there weren't very many in my undergraduate years, and it was hard to relate sometimes to science or scientists as a whole. My supervisor is a woman, I could work with a male supervisor. That would not be a problem. But it is just great to know that there are women in the school of physics now and it is great to see someone doing what I would like to do because I think if I didn't have any female lecturers it would have been very difficult to know that it would be okay for me to be a scientist. It is just really nice seeing people who look like me.*

For Kathryn, having a female lecturer in the school of physics is related to increased implicit science identity, so she knew 'it would be ok for her to be a scientist' because she had a female lecturer. Seeing women in her academic field reduced gender stereotypes and presented a strong role model for her, as she expressed herself: "It's nice to see someone doing what I want to do." ‘Someone' in her talk refers to women in the physics department in general.

Demi's narrative provides another example of the inspiring effect of positive role models on women's science career advancement in academia.

> *Isla the woman who put me into contact with you is a brilliant woman. If you look at most Ph.D. papers, if you look at certificates on the wall, her name is there. If we have a meeting with my manager and different PhDs, if they are talking and they are explaining something to me, they always look to Isla to see if they are right even though they are supposed to be the same level.*

During the interview, Demi often told me how encouraging and privileged for her to work with Isla whom Demi found very successful and ‘brilliant’ in physics. Isla is a positive role model for Demi because she associated herself with the successful image of Isla.

**Section summary**

This section seeks to answer the research question “*What are the challenges faced by them arising out of incompatibility between gender-science identity?”* by analysing it under the main theme *Struggles* which was divided into four subthemes: *maternity and child-care, low-level self-confidence and imposter, anxiety of proving, limited or lack of role models.*

Under the subtheme ‘*Maternity and child-care’* the narratives of the participants centre on the issues of pressure to publish all the time, lack of role model, lack of job stability due to short-term contracts, vague policies around parental leave, work-life balance, and disparities between men and women in terms of child-care and parental responsibilities. The comments from the participants also indicate that traditional gender roles still exist and place stress on women’s shoulders. Based on the participants’ narratives, the societal expectation around women’s familial roles (caring) and motherhood often conflict with women’s scientific career at an early stage in academia. As a result, in many participants' narratives, motherhood and science identity may seem to be conflicting forces.

The subtheme *'Low level of self-confidence'* focuses on the participants' beliefs in their scientific abilities. I have observed that although the participants reported that they had been quite good at mathematics and science from their childhood, and their competence was approved by the exams or by scientific others, they felt that they were not 'good enough'. All of them associated low self-confidence with gender stereotypes and largely male-dominated work-research and study environment of their academic disciplines. All the participants compared men and women in their class, research centre, conferences, labs, and workplace. Men do not doubt their ability, while women are afraid of failure, according to them. Furthermore, although all participants, regardless of age or degree of study/work, reported low or lack of self-confidence, PhDs and postdoctoral researchers used the term 'imposter syndrome' more frequently than 'low/lack of confidence'.

Another subtheme was *'Anxiety of proving'* which was linked to low self-confidence issues. Based on the participants' narratives, I believe the need (urge) to prove themselves to people within and outside of science was a defensive and emotional reaction to male dominance, gender, and racial stereotypes, as well as related biases. I found that some of the participants who are subjected to gender and racial prejudice try harder to prove themselves in order to overcome the bias. The women interviewed claimed that they were working harder than their male counterparts and peers to justify their place, persuade others of their accomplishments, and be recognized and valued. The anxiety of proving is not something that discourages them from progressing in science. Instead, it may put extra stress on women's shoulder on the way of becoming a scientist as they are often reliant on external affirmation to prop up their confidence.

When asked about influential role models, the participants did not identify distant role models such as popular award-winning scholars or well-known scientists in the media, according to my study of the participants' narratives under the subtheme '*Limited or lack of role model.'* Instead, they articulated someone close to their academic circle, who may have a similar background: a woman lecturer, professor, or researcher who they can be inspirational for their future science careers.

### 5.4.3 Section III: Research Question III

The research question that guided the analysis and presentation of findings in this section was:

***What is the role of the feminist movement on women's science identity development?"***

Two main themes emerged to answer the research question above: 1) visibility and women's network, 2) the discourse on 'women in science'.

Some of the participants identified as feminists, while others did not, but both groups contributed to the study by participating in the interview and sharing their perspectives and experiences with me. Feminism is a controversial concept in and of itself. It encompasses a wide variety of social, political, and ideological movements.

The participants did not arrive at a common understanding of the term 'feminism', because the word itself is very multidimensional which encompasses feminist self-identification, feminist consciousness, and gender role attitudes (McCabe, 2005). My aim was not to judge women's feminism self-identification. Instead, in recent years, the feminist or women's movement has been so strong in science that it could have an effect on women's science identity development. The women's movement (whether or not it is labeled as feminist) has been drawing attention to women's position and contribution in science, especially in the last few years since I began this research. It has also sought to work on long-term solutions to the challenges that women in the sciences face.

The responses of the participants were analysed for common themes regarding the role of the feminist/ women's movement in science in the development of their science identities. Initially, I could not reach a common understanding amongst the participants around ‘feminism’ and ‘feminist identity’. Their opinions and feelings change depending on the situation. Then, I decided to find the phrase ‘women in science’ across the conversations, because I remembered that it occurred many times during the interviews. So, I made up the theme ‘discourses of women in science’. The theme of ‘visibility and women's network' was easier to see because they mentioned women-specific groups in their disciplinary field whenever they spoke about feminism, and how these groups help women gain visibility and provide networking opportunities.

**Theme V- Visibility and women’s network**

The feminist movement can be a collective action as well as individual resistance. In both cases, in its core, it tries to make the individual’s or groups’ identity publicly visible. Through the analysis of the narratives of the women’s interviews, I came to realize that visibility is important for them. The participants agreed that women's visibility in the scientific community should be increased. It can be by collective action, individual awareness, and agency, exchanging experiences, speaking up, or simply being, as the narratives below demonstrate. Despite differences in cultural and social backgrounds, country of origin, age, and level of study/research among the participants, they all shared their experiences and perspectives with me in order to make them publicly visible. Participants reported that "women in science" organizations offer networking opportunities, advocate for representation, and raise awareness.

Diane (BA) spoke of a panel organized by the student union in her university last year where they invited some female professors and speakers in STEM. She found it quite interesting and engaging. She said: "*it was good to hear some of my professors talk about where they come from and if they didn't come across any difficulties as women"*. During the interview, she often expressed that it is very important for girls to build networking and a sense of community for their visibility, representation, and involvement. Diane herself was very aware of the women networking societies in her university and actively engaged in them. She said female networking events would create a community that women can feel 'comfortable' and 'motivated'. She tried to start a society for 'women in science', but it was failed as 'women in STEM' society was already covered in her university.

At the time of the interview, Lara (Ph.D.) was actively engaged in women in science groups. She commented:

> *I have been so involved with women in science groups and women in science events. I am an executive committee member of WITS Ireland and like doing so much work for them and going to so many events where we are trying to battle women's unconscious bias and we are trying to help these women whose confidence is so low and they cannot see themselves as scientists. We are trying to tell them no, you are basing this on all this bias that you have and that you have grown up with and you have grown up in a society that you are just totally surrounded by that.*

Lara is a mentor, a teacher, and a scientist, all of which she identifies with. Lara admitted to having imposter syndrome and that she was working on it. Her role in women in science groups, as previously described, also includes assisting women with low self-confidence. Lara believes that mentoring is based on interaction, which means that she encourages and empowers other women while also empowering herself.: Lara's feminist and science identities overlap and complement one another, as she explains below:

> *Feminism is a huge part of my gender identity and it comes into play in my, I guess, science identity because that leads me to do all this work with women in science groups.*

In the narrative below Lara told me how the 'women in science' conferences provide a support network for women at all levels in their academic path. Lara attended a conference for undergraduate women in physics which was very inspirational for her. She described the conference as a 'support network' where she was surrounded by other women in the field of physics..For Lara, the most inspiring aspect of that conference was seeing herself as one of those women in the future.

> *I went to a conference for undergraduate women in physics. So, it takes place in Oxford every year, it is to encourage women who are studying physics to feel confident in their degrees and to stay in their degrees. And it is just a support network. I went to that and I could not get over how it felt not only to be surrounded by physicist women to be sitting in a lecture hall. Like it is all women sitting there. It was only at that conference that I actually thought about what my life would be like if I had their job.*

Many participants stated that 'women in science' groups benefit them in a variety of ways, including sharing experiences, encouraging professional development, networking, and casual get-togethers. Some of the participants mentioned that their college hosts a pizza night for 'women in physics' every year. They can meet other women in their academic circle and share their experiences at this informal gathering.

> *Every year the school of physics has women in physics pizza night. I have gone every year since I was the first year. When I was a first-year, that was four years ago, it was the first year that they had only two female professors. Just four years later, there were I think five female lecturers that were out at this pizza night. (Molly, BA)*

> *There is a 'women in physics pizza night' organized, which I think is a great thing. Last time, there was actually a lot more girls than expected. So, it had the professors and all the undergrads and the postgrads and then the woman who organized that. She is one of the top professors in the school of physics. (Joan, BA)*

Molly and Joan both emphasized the representation of women by number in their college's "women in physics pizza night," as evidenced by their narratives. During my interviews with the participants, I learned that having a growing number of women in their academic field is important to them. Even if progress is slow in some fields, such as theoretical physics, it is still important not to feel 'alone,' because feeling ‘alone’ can lead to feelings of isolation. As Kathryn (Ph.D.) said, *“It is hard to explain to someone how you feel weird. If you are the only one you feel like you are representing the whole gender”.* So, even if it is local and informal, ‘women in science’ organizations can help women feel more integrated and represented.

The participants stated that physical sciences, especially physics, is dominated by white men. However, most of them also commented that this is not a hostile environment where they are disrespected or oppressed. One of the participants referred to physics as a ‘boys club.’ Another participant stated that it used to be a man's world, but that it is now gradually changing. Women may seek a space where they can raise their voices or simply share their experiences in a male-dominated work, research, and study environment.

Lou (postdoc) was involved in female-specific Ph.D. support groups when she was a Ph.D. student. She commented:

> *I think something that definitely helped me was finding some people who felt the same way and experienced the same things. It made a huge difference in me to find some support during my Ph.D.*

We did not spend much time discussing Lou's preference for a female-only support group, but she did tell me during the interview that it was where she felt most at ease. In the excerpt below, she emphasizes how other Ph.D. women's ‘shared experiences’ helped her mirror her own experiences as a Ph.D. science student.

> *Finding women that are experiencing the same thing helps me analyse them and myself in the same way, and it makes a huge difference, really huge difference in me.*

Samiya and Neha (both PhDs) evaluated women’s networking and support groups in science as ‘eye-opening’ and ‘awareness raising’. Samiya expressed that *“sometimes you don't think you are going through something and you don't realize that it is a common issue until you meet other people having the same problem”.* My research, according to Neha, is a platform for her to raise her voice. She expressed:

*If I have the opportunities, I would raise my voice, or I would take part in the study like yours.*

Samiya and Neha both stated that they did not participate in any feminist science organizations, aside from a few informal gatherings at their college. They were engrossed in their Ph.D. research, as they were in their final year. They were already anxious due to their heavy workload and time commitment to their research. They both stated that when I contacted them for an interview after explaining my research, they thought it might be a good opportunity for them to share their perspectives and experiences as 'women in physics.' For them, the interview was an informal feminist get-together to which they might contribute.

Roda (BA) stated that the feminist movement is important for people to acknowledge that '*we*' exist. "*It is like you have a gossip in one room and it'll inevitably go into the other if you have the door open,*" she said, emphasizing the importance of collective action. Roda needs a greater drive than simply waiting for things to improve. She said she was heavily interested in outreach programs and 'women in science' organizations as a result of this. She commented:

*I also think by acknowledging women, particularly in science and physics, you are more likely to get people to acknowledge other groups who are not represented either. I think it is always an important thing to challenge.*

*I do a lot of outreach work. We hold workshops for primary school and secondary school children who come from disadvantaged schools. We do science demonstrations with them for an hour.*

*I think you have got much more effective if it happens from children who are in primary school who don't even realize that gender is a thing as opposed to even by the secondary school it could be too late and by the time you come to college like it is very hard to change some people's minds. I also think particularly when so many girls, just think that it is just not something for them or just don't think that physics is a thing that they could ever do. That is really damaging.*

In the narratives above, Roda considers feminism as a movement for gender equality but also an inclusive movement for other underrepresented people as well. She was referring to people from marginalized backgrounds when she said, "other groups who are not represented either." Roda repeatedly told me during our discussion how necessary it was for her to make the ‘underrepresented and marginalized groups' visible by not referring to ‘women.' She listed stereotypical attitudes of girls toward physics in her last quote, which she believes must be challenged. It was 'damaging,' according to Roda. Roda stressed the importance of a female role model as a lecturer or professor in her potential career path choice in the interview. Her participation in outreach work, in my opinion, stems from her desire to be a role model for younger students who believe that physics is not for them. Roda's science identity is shaped by strong role models that came before her, as well as her own role as a role model for the younger generation.

**Theme VI - The Discourse on ‘women in science’**

The science identity of women includes both women’s sense of self and how women in science as a group are defined. Through my analysis of the interviews, I noticed that, depending on the situation, the ‘feminist' or ‘woman' tagline in the sense of science can be harmful as well as helpful and empowering for women.

The participants largely identified as feminists, and they are all in favor of equal opportunities in science for all genders and sexes. However, because of negative stereotypes about feminism, some participants distanced themselves from feminism and the feminist movement in science. ‘Women in science’ as a feminist label, they believe, harms women's careers in science. However, for some other participants it is used to boost the visibility of female scientists, which benefits women’s career advancement as well as their science identity development by providing them with a public platform to be seen and heard.

When I asked Roda (BA) if she felt comfortable being referred to as a 'woman in science,' she said:

> *If it is a friend of mine who I know is also a feminist and into gender equality and stuff, I would not mind because they don't see women as a negative word. For lots of people, when they see the tagline women, it is like, oh it is an easier thing. Or oh look, she is getting courageous because she is a woman, not because she is doing stuff. I think that can be quite damaging.*

Roda stated in the above narrative that the tagline 'woman' can mean different things to different people. She would be comfortable being referred to as a 'woman in science' within a feminist community because people are already aware of what it means. However, as Roda pointed out, the phrase 'women in science' becomes vulnerable when it is used by those who believe that becoming a 'woman' is a 'easy' way to advance in science. Roda called it 'damaging' because the tagline's use of the word 'woman' has a negative connotation in that sense. She further commented:

> *I have been lucky, and I live in a nice little liberal bubble and look like all my friends like yay gender equality. But imagine that when I go back into the working world or whatever, and if people like see like the women tag as being a negative thing, then I probably wouldn't like it as much as I do. I don't think that actually means anything different, but it is just whatever people associate with words.*

In the narrative above, Roda emphasizes the discursive and performative aspects of the words. The meaning of the words is determined by the context, situation, and speaker. As a result, from Ruth's point of view, the meanings are established by people. She is unsure whether she should embrace the tagline 'woman' because it is synonymous with something negative for certain people outside of her 'little liberal bubble.'

Roda's narrative mirrors the experience of Aine (Ph.D.) who earned an internship position in the European Space Agency during her master's. She said one of her male colleagues who was rejected for the same position commented about fulfilling a quota for Irish women, because he said that there had to be a certain amount of each nationality and gender balance was needed. Aine expressed that it really hurt her feelings.

> *You don't know whether you were better than them or just you were fulfilling a quota. That gives you like self-doubt. That is why I think a lot of women start to hate these kinds of positive discrimination things and 'women in science' labelling because they want to be the best because of their own pride.*

Aine went on to say that after becoming aware of the feminist contribution to science by conferences by women in science and through informal workplace discussions among women that she changed her mind about 'women in science' tagline and the feminist movement in science. She commented:

> *I have gone through like a mental shift there and I would say in the last two years where up until that point I was extremely proud and not wanting any help. When someone says like, oh, you are a woman in science, I would just be like, I am a person in science. I don't want any kind of word or let's not have a pizza evening just because you have boobs and you also do science. That just really bothered me because it was kind of already putting the attention back onto you when you're just trying to be one of the scientists. You don't want to be labelled with your gender.*

Aine stressed the distinction between a 'woman in science' and a 'person in science' in the following narrative. She was against assigning a gender to a scientist and engaging in activities aligned with that gender category because she felt it was focusing emphasis on the scientist's 'gender identity' and 'gendered self' rather than the career itself. Aine was concerned that her identity could be a barrier to her professional advancement. Since participating in feminist discussions in her academic community, her perspective totally shifted.

> *Now as of recently I have had like more of a shift and this conversation has had so much in our office or conferences by women in science. And it is only through talking to other people that have kind of realised the amount that women previously have fought to get us to where we are and where I don't have to worry about it. I have never realised that it was such a big deal. And we have to kind of continue fighting for the next generation until it is more like 50/50 balance.*

In comparison to other sub-fields of physics, Aine claims that gender balance in astrophysics is not as low. She told me in the interview that she became more aware of gender inequality in her academic field when she advanced to a higher degree, such as a Ph.D. When she noticed it, her attention shifted to the gender and representation issues, As a result, she became more interested in gender discussions within her academic community.

Similarly, Nicole (BA) noted that she was not very active in promoting herself as a woman in science, but she said that seeing online of those acts such as promoting women in science would make her feel 'appreciated' and 'nice'. She went on to say:

> *I am a scientist, but until there is half / half, I think women in science draws attention. Why do I need to say I am a woman in science? There is not 'men in science', because men are everywhere.*

Nicole, like Aine, was interested in equal representation of women in science. The 'women' tagline, in her opinion, brings public attention to the need for recognition and equality.

For Molly (BA) 'women in science' tagline creates a space for women to connect with other women to share their experiences and support each other as well as building a role model for the younger generation.

> *I think that me being a woman in science, I think that gives me the opportunity to both connect with other women in science or similar experiences. It allows for kind of a structure of a support system. Also, it allows younger girls to look up and say, look at these really cool women in science.*

In Molly's narrative, gender is not a passive category. Instead, it remains an important identity position for interpersonal relations, personal awareness, and inspiration for the younger generation. So, the 'women in science' tagline is associated with positive connotations, in her case, which empowers her science identity.

Unlike Molly, in Demi's (BA) case, gender remains contradictory beneath the practice of science. Demi self-identified as a woman. She told me that she had a male kind of features, motivation, and a sense of humour which may be the reason why she fit physics. On the other hand, she was very much aware of gender imbalance in her disciplinary field. She described herself as a woman in her academic circle as being in the minority.

In her mind, the word 'feminine' and 'feminist' evokes cconfusing and inconsistent connections of physics, thus feminism or gender-related discussions are not approved by 'people' of her social environment. She noted:

> *I naturally tried to stay away from feminism and from the word feminism because just if you just mentioned it, the conversation closes, you know, people don't want to listen to it.*

We did not go into detail on who she meant by 'people' in the above narrative, but Lara (Ph.D.) told me a similar story. Men in Lara's social or academic environment (she did not mention it) do not see gender disparity in physics as an issue, so they refuse to speak about it, as she noted in her narration below. As physics is overwhelmingly male-dominated today, equality or feminist talks are only approved in a '*little liberal'* groups where people are ok with '*gender equality stuff'* as Roda explained in the previous theme. Apart from that, it is ignored, as seen in Lara's narrative below.

> *I know for a fact if I am having a conversation with the guys and I started a conversation with oh, there are not enough women in physics, women are put down… all of them like oh, I don't want to talk about this. Whereas if I start the same conversation with women, they are dying to have a conversation with you. So, if you are in a setting where you are one of the few women amongst a lot of men and you are the woman who is saying all of this gender equality stuff it is like you are talking ridiculous because they are like everything is fine.*

It can be seen from Lara's narrative that when you are a minority in a community, the majority who have not faced the same challenge as you can silence your voice. As a result, in science, where men outnumber women, if you are the only woman in a group discussing gender equality, you would most likely be ignored as if this were not the case. Thus, women create their own spaces in which to discuss the challenges that they face.

Demi noted below that to most people outside of the feminist circle, the feminist movement in science seems to be ‘exclusive’ rather than ‘inclusive,’ and that it is seen as a "little party" for women only.. She noted:

> *I think that because of the kind of the feminist movement, a lot of people would look at those events and things like, all right, so men are excluded. It is just women and science. It is their little party because they are kind of scientists. I am not familiar with a lot of things, you know, because I am just living on a daily basis and I never reached for women support groups and maybe they would be very good and maybe they would give me more motivation. I just kind of stay away from them because as I have said before, even if I have a feminist attitude to some issues, I still stay away from feminism in general because of what it means nowadays.*

Despite her explicit distancing from feminism and feminist activities, such as ‘women in science' events or ‘women support groups,' and the fact that she often constructs herself as a woman ‘having masculine traits' in order to place herself as a physicist, Demi still holds feminist attitudes to some issues in science, such as gender stereotypes, and the under representation of women in science. Our previous discussions have been consistent with her feminist views and attitudes.

Similarly, Reese (BA) noted that “*people have a big objection to the word feminism.”*. As a result, the tagline ‘women in science’ could seem feminist to others. They can respond negatively to a ‘female scientist’ or ‘woman in science.’ Reese stated that it was also the women's unique experiences in science that distinguished them from the ‘scientist,’ which is gender-neutral.

> *Sometimes you just want to be a scientist, but your experience is different because you are a woman and that is why you call yourself a woman in science. I suppose context matters so much with that because some people could be like, oh, you are being awarded for this because you are a woman. And she is like, no, I am being awarded for this as a scientist and I am also a woman.*

After analyzing the conversations with some of the participants, I found that 'gender labels' for women can be harmful to them if the focus is on their gender rather than their career. Reese said in the interview that the tagline 'women in science' is contextual and situational. If too much emphasis is placed on a woman's gender, her 'science identity' is concealed underneath her gender identity.

As a result, their 'scientific success' can be overshadowed by their gender In Shalini's (MSc) words:

> *When a woman wins something in science, it is considered as history and it is like, oh, you did a great job that nobody could. I am not proud to be called like that, you know, like a female scientist. I am not a name to be kept in the museum. I want to see myself as a normal scientist, an energy scientist.*

Shalini was suggesting in the above narrative that anytime a woman accomplishes something significant in science, it makes headlines with an emphasis on her 'gender/sex,' as if science were a man's domain. For Shalini, women's achievement is regarded as exceptional when they are visualized as a 'female scientist' rather than 'normal scientist'. I did not ask Shalini what she meant by a 'normal' scientist, but in this case, it applies to a gender-neutral profession. Shalini believes that portraying women in this manner (putting so much focus on their gender identities) undermines their scientific identity.

**Section Summary**

All the participants who participated in this study were supportive of equal opportunity and feminist concerns, as feminism is viewed primarily as an ideology of equality, to them. However, some of the women did not want to define themselves as feminists because of its negative connotations or the ambiguity around the term 'feminism'. During our conversations, even those who did not wish to specifically describe themselves in terms of feminism accepted a number of feminist concerns in science and identified with many of the feminism's values.

Other social identities, life experiences, or cultural backgrounds have no impact on attitudes toward feminism or the tagline ‘women in science.’ Equal opportunity, gender balance in science, equal representation, fair participation in senior roles in academia, positive female role models, support networks, and combating gender biases and stereotypes in science were all supported by the participants.

I noticed that the labels of ‘feminist’ and ‘woman’ favor women in terms of empowerment, shared experiences, support, networking, visibility, representation, and supportive role models after analysing the comments of the participants. This way, women can develop a public voice and build a community to speak out any challenges they come across or to feel less isolated and support each other where they are underrepresented. On the other hand, it may overshadow their ‘science identity’ when the focus shifts from their achievements to their gender

# Chapter6 : Discussion in the light of the literature review

*"The unread story is not a story; it is little black marks on wood pulp.*
*The reader, reading it, makes it live: a live thing, a story."*
*Ursula K. Le Guin, Dancing at the Edge of the World: Thoughts on Words, Women, Places*

## 6.1 Overview

The purpose of this study was to explore how science identities of women, who are at the early stages of their studies or academic career path in physics and physical sciences, are developed and performed related to their gender identities along with their other social identities. Their challenges along the way of becoming a science person/scientist/researcher and the role of the feminist movement on their science identity construction were also explored. This study addressed the following research questions:

1. How do female students and early career researchers in physics and physical science fields in higher education construct their science identity related to their gender identity?
2. What are the challenges faced by them arising out of incompatibility between gender-science identity?
3. What is the role of the feminist movement on women's science identity development?"

In particular, the analysis of the participants' narratives focused on their self-evaluation of science identities related to their gender and other social identities, self-identification with science, their expectations and struggles as well as the role of the feminist movement on their science identity development.

This chapter summarizes and discusses the research findings through the theoretical framework of this research.

## 6.2 Research question I

➢ *How do female students and early career researchers in physics and physical science fields in higher education construct their science identity related to their gender identity?*

There are some key findings to address the research questions above. Related to this question, the analysis of the participants' narratives led to three emergent main themes which were discussed in the previous chapter (see Chapter 5): sense of belonging to science, doing science, doing gender.

The previous studies have shown science identity to influence persistence in science careers for undergraduate and graduate students (Stets et al., 2017; Carlone and Johnson, 2007; Merolla et al., 2013; Pedone, 2016; Hazari et al., 2013) as well as for postdoctoral researchers (Hudson et al., 2018). My research centered on how 'science identity' construction and development is shaped from a gender context in my study of the research question above. This is particularly important for a better understanding of how it functions in women's participation and persistence in science.

### 6.2.1 Sense of belonging to science

In the narratives of women, a sense of belonging centred on how they feel about science, how they feel in a scientific community, and what attracted them to science. A sense of belonging was further categorized into two components: emotional attachment and community attachment.

Emotional attachment to science was based on the participants' interest, passion, enthusiasm to their disciplinary area as well as their feeling of competency which I revealed as a motivating factor for them to enter, progress, and sustain in science. Community attachment to science meant to be a feeling of being a member of a scientific community for them which positively contributed their development of strong science identity but identified as less 'influencing' compared to their emotional attachment to science.

From their early years, their curiosity and enthusiasm for science and the feeling of competency have a positive effect on their motivation to advance in the scientific field and to create a positive identity for science. The participants used strong descriptive words to express their interest in their academic disciplines. (e.g. I am passionate about it, I fell in love with it, it is amazing, I love it, it is so cool, it is very interesting). This finding is consistent with Potvin et al. (2013) result that interest is central to science identity.

All the participants except Demi who did not study science until college stated that they were good at science and mathematics in primary and secondary school. Their interest and sense of competence positively influenced them to choose a science major at college. Engaging in science activities in their early years at school, at home, with their peers, or with their parents became the first step in forming their science identities, regardless of their level of study, academic status, academic discipline, or age.

Along with the factor of interest, a sense of competency also influenced the participants moving to develop a science identity as a first step. All the participants self-evaluated their mathematics and science competency in secondary school and for the leaving certification as above average. "I have been always good at mathematics and science" was repeated by the majority of the participants during the interviews. Later, in their college years, they were attracted by a variety of scientific activities: labs, discoveries, hands-on activities, experimental aspects of science, making things work, analytical and practical works.

All the women who participated in this research had already chosen science careers and studies which shows that they already possessed scientific competence. Majority of the participants possessed a strong recognition of themselves as a scientist, especially at a higher level (e.g. Ph.D. and postdoc). All undergraduate students participated in the interview considered themselves science students on the way of becoming a scientist. However, it was found that especially at the undergraduate level, the classroom and faculty environment (numerical and normative dominance of men) and gender stereotypes hit their self-esteem and confidence. At a higher level (Ph.D. and postdoc) the confidence issue was replaced by imposter syndrome. Confidence and imposter syndrome were discussed in much detail in the next section.

In previous studies, it has been found that young people tend to associate most science careers with masculinity (Archer et al., 2012), with children perceiving science as being for boys (Francis et al., 2016). In another study conducted in Ireland (McLoughlin et al., 2015), it was found that 44% of students identified the perception that STEM subjects are more suited to males than females. This study result of McLoughlin et al. is in line with Archer et al.'s study. Some participants in this study established a connection between masculinity and science especially in their early years and before they academically engaged in science.  Participants who were studying or studied physics often emphasized ‘the fewer number of girls’ choosing physics class compared to the girls choosing other science courses at school. Here, I would particularly like to emphasize the phrase of Lara (Ph.D.) to explain the feeling of isolation when your interest is different from what society expects your interests to be. “no one wants to do the subject they love if they feel like they are going to be like an outsider”. Her statement says so much about how important it is for individuals to love anything to sustain it. Breaking expectations is difficult when your desires and talents vary from what society expects. I claim that physics and physical sciences which are still seen as traditionally masculine and hard domains need a strong interest. The high level of interest and passion described by the participants enabled them to progress in science as can be reflected from Neha’s (Ph.D.) statement: *“I love it. Otherwise, I wouldn’t survive that long. Being a scientist is like my passion”.* The participants were inspired and encouraged by their intense excitement along with their pleasure of accomplishment and sense of achievement on the way to establishing their identities in science.

When it comes to community attachment to science, how the participants feel recognized, valued, respected, and accepted by scientific others within their science community as well as other people around them were also expressed to be a contributing factor to construct a science identity. Some of the participants discussed their science identities in comparison to others (e.g. their friends, colleagues, people in higher positions). This is where their gender and other intersecting identities appeared more.

The majority of participants described science as a ‘team effort’ and explained their (ideal) participation in the scientific community with phrases like ‘building relationships with other members,’ ‘sharing ideas,’ ‘building a network,’ and ‘having good communication with people,’ indicating that women prefer the communicative and cooperative aspects of science (For more information, see the ‘community attachment to science' theme in Chapter 5). The narratives reveal that supportive and encouraging group of people within their scientific community positively influenced their motivation and helped them develop a strong science identity. However, only a few of them expressed that they experienced such a supportive and encouraging science environment. They mostly shared with me an ideal picture of the scientific community in their heads they would like to be engaged in or they wish to be a part of.

From a gender perspective, the findings reveal that a feeling of ‘fit in science’ and getting meaningful recognition from scientific others as well as from other people was problematic for the women in this study because it depended on an external audience. The majority of the participants stated that they received a sign of shock or surprise from other people when they introduced themselves as a scientist (particularly a physicist) especially if they have (intersecting) underrepresented minority status. In the context of a college setting, at the undergraduate level, the participants compared themselves with their male friends in terms of getting the equal opportunity (one of the participants said boys in her class were placed for internship positions earlier than the girls even if some girls had the higher grades), sense of self-confidence and proving their scientific skills.

At a master's and Ph.D. levels, some participants expressed their frustration upon hearing sexist comments from other people in the conferences. They also stated that they felt isolated from the rest of the science community in conferences as the majority were white men in senior positions. Also, at the Ph.D. and postdoctoral level, the participants complained that there are few women in their research group or top roles within their faculty. As Kathryn (Ph.D.) said, "It is hard to explain to someone how you feel weird. If you are the only one you feel like you are representing the whole gender". I have concluded from their narratives that it allows them to feel a greater sense of belonging when women see other women within their academic and scientific community.

From an intersectional perspective, the feelings of isolation and alienation of racial, ethnical, and religious minority women in this study can be associated with uncomfortable feelings with the scientific environment as well as with being exposed to certain stereotypes (from both scientific and non-scientific others). For example, one of the participants (Julianne) described her social environment in her colleges as her 'comfort zone' as it is more international than the outside world. Even within her 'comfort zone', she needed to prove her scientific skills and abilities to be valued and accepted by scientific others in her department. Outside of college, she racially stereotyped as 'not a scientist' as people from her origin of country work in the service industry by a great majority in Ireland. Both at Ph.D. and postdoc level where the participants are expected to have a scientific competency and knowledge was viewed as 'less educated' and 'less capable' by their peers, faculty members, or people outside of college. Participants who identified their ethnic identity as not "western" as well as the participant who dressed hijab often reported a diminished sense of belonging to science community when compared to other participants who were not marginalized within science environment characterized by the mainstream, dominant culture of science. This result is consistent with Avraamidou's finding (2019) that for Muslim women, especially when their religious identity is visible (e.g. choosing to wear a hijab), it might serve as a barrier to their recognition within a scientific environment. Thus, they may be at risk of "falling between the cracks" as a result of Western academic institutions' inability and refusal to accept multiple identities from coexisting, especially in male-dominated and overwhelmingly White fields such as physics (Avraamidou, 2019, p. 28).

Participants from underrepresented groups also stated that they are double-stereotyped in science when gender intersects with their other social/cultural identities. The participants have stated that if 'you are not white, man and western' you feel like you need to prove your scientific skills in order to be recognized as a scientist. "Once they are convinced by your work, they leave the stereotype behind" said Jill (PhD). This finding supports the argument made by Banchefsky et al. (2018) that the negative ideologies position the dominant subgroups—White men—as superior and normative, further marginalizing women and racial minorities. Thus, increasing the number of underrepresented groups in science is important in terms of eliminating negative ideologies and stereotypes towards minority groups. Stets and Burke (2014) claim that identity verification, which means having to do with social belongingness and integration, including being accepted and valued, is central in the identity process. So, for a scientist, being valued, accepted, and known by significant others are important in terms of increasing the sense of belonging and identifying themselves with the science identity.

Good (et al. 2007) have suggested that the feeling that one fits in, belongs to, or is a member of the academic community influence college students' intent to pursue related discipline in the future. In their study which focuses on math identity, they found out that women's lowered sense of belonging negatively influenced their intention to pursue a future mathematics career. However, their math ability was found out to protected women from negative stereotypes, allowing them to maintain a high sense of belonging in math and the intention to pursue math in the future. In my study, it is the individual passion and interest towards science along with a feeling of accomplishment especially at higher levels (Ph.D. and postdoc) that allow women to continue despite their diminished community sense of belonging. They made a personal connection between their field and themselves rather than their personal relationship with scientific others and their science identity.

Participants in this research, especially those in the postdoctoral stage, thought of themselves as competent scientists. Even though the majority of them questioned the full integration of women into the scientific community in their disciplinary field or in general, they appeared confident of their status as scientists and never questioned whether they "fit in research." This result was detected as different than undergraduate students who may face a lot more challenges in establishing their capabilities as legitimate scientists. Their commitment to science identity was identified as less dependent on others' perceptions compared to undergraduate and graduate students. In Hazari et al.'s study (2020) which focused on the physics identities of female undergraduate students, the findings revealed different level of sense of belonging between senior and junior level physics students. The findings (Hazari et al., 2020 show that for both groups, the feeling of belonging shift and evolve in together with their feelings of competence and recognition. Thus, senior students have a greater sense of belonging than junior students, which contributes to the development of a stronger physics identity. In my study I observed that at a higher level (graduate and postdoctoral level) the participants considered themselves to be legitimate scientists and scientific researchers, while their sense of belonging to the scientific community in general did not indicate a substantial difference from that of undergraduate students. In contrast to Hazari et al.'s study, sense of belonging is not always tied to competence and recognition. Especially at higher level, the participants were more confident about their scientific skills can be used to achieve recognition in their scientific community, but they still indicated a feeling of alienation and even exclusion (depending on their minority status) from their scientific community.

The participants did not vary in their emotional attachment to science depending on their level of study/research. Regardless of their study/career level, their sense of belonging to science is strongly related to their interest in science. In terms of community attachment to science, their sense of belonging is closely linked to how integrated they feel in their scientific community. The disparities among the participants are at individual level and are based on their personal experiences rather than their career/study level.

### 6.2.2 Doing science

Performance, another salient aspect of science identity was analysed through a gender perspective in this study. The themes *doing science* and *doing gender* (see Chapter 5) which emerged as the main themes to explore practical and performance aspect of science identity focused on how the women participated in this study view scientist in general and view themselves as a scientist, how they engage in scientific activities, and how they define /perform their gender within the context of science.

People perform their identities by engaging in identity-related activities and works (Gee, 2017). Gee named it as an activity-based identity described by both a noun (for BEING) and a verb (for DOING) such as 'scientist do science'. Below the general label, the large amount of diversity is hidden. As for science identity, through performance individuals act like a scientist, participate in scientific activities, think like a scientist, demonstrate their scientific competence, and apply it to their knowledge and skills. At the same time, the label 'scientist' is not stable. It is based on repeated performances and socialization into the discourse practices of science.

Consistent with previous studies (Kim et al., 2018; Brown, 2004; Robinson et al., 2018) it has been found that science identity is an ongoing and actively engaged process. Women who participated in this study construct, develop, and perform their science identities by actively participating in scientific activities, through interacting with colleagues and broader disciplinary communities, demonstrating scientific skills, as well as defining and shaping what and who a scientist is. For this reason, how they view scientists and how they view themselves as a scientist is highly important in influencing (shaping) how they do science. I have found a strong correlation between how they describe themselves as a scientist and how they do science. Given this study's gender focus, how they define and describe 'women' and their perception of 'women in science' were also important.

Participants' descriptions of scientists revealed two types of discourses: the image of a scientist and the personality traits of a scientist. Another interesting finding of this research is that the majority of them assign different stereotypical image to scientists and physicists.

Overwhelmingly, participants in this study described scientists as creative, hardworking, determined, dedicated, problem solver, passionate, curious, patient, and inquisitive. The discourse of personality traits of a scientist seemed to be fit with the actual practices that participants engaged in and their actual work of doing science. For example, the participants who were doing a Ph.D. in Optics described their works as 'exacting' which demands 'hard work' and requires great 'patience' and effort. Neha who was a final of Ph.D. in Optics described her work as experimental which, in her own words, explained as such: "*I build my optical setup and I rebuild my system may be more than a hundred times to get like less than one result"* (See Chapter 5). Her description of her Ph.D. project as high demanding and her description of a scientist as ‘hardworking’ and ‘patient’ showed that she constructed the personality traits of a scientist through her scientific work. Another example is that (as discussed in Chapter 5) Natalie described a scientist as a problem solver who solves physical problems such as making inventions and making things work. Natalie was doing an internship in an industry at the time of the interview. She said she was always interested in hands-on stuff and the experimental aspect of science. She constructed her description of scientists both through her interest and capability as well as through seeing scientists who ‘make actual thing’ during her internship experience. Their narratives have demonstrated that there is a strong link between their personality description of a scientist and the way they do science or the way they want to do science.

Based on the analysis of the participants’ narratives I have come to the conclusion that their enthusiasm for science stems from their love of doing science and the inquisitive nature of a scientist, regardless of how difficult the scientific tasks might be. For this reason, they used optimistic and positive adjectives like creative, hardworking, problem-solving, dedicated, etc. to characterize a scientist.

In a study by Archer et al. (2010), it was revealed that most of the children (aged 10-11) reported enjoying science at school and this enjoyment was predominantly framed in terms of the practical mastery of ‘doing science’. Their research also demonstrated that although they enjoy science, they may still see it as ‘not for me’ and choose not to study it at a higher level. In my study, the focus group was women who had already developed a certain degree of interest in the field of science. They all expressed their strong interest in science both in their early school years and later in their college years Similar to Archer’s findings, they all reported a strong connection between doing science and enjoyment of it. That is an important factor in shaping their science identity. Differently, in my study, they also reported a connection between how they view a scientist by personality traits (description of a scientist) and how they do science (doing/practicing science). This connection which may be developed in early years or later in college years can be regarded as a strong factor that keeps them engaging in scientific activity and building a science identity.

Analysis of the data showed that the physical appearance of a scientist is gendered and stereotyped in contrast to the personality traits of a scientist. They have reported that a stereotypical picture of a scientist, which is heavily white and male in senior position and working in a lab, discourages them but they also question and try to challenge it. This finding is consistent with Lederman et al.'s (2001) description of a stereotypical image of a scientist as 'white, middle/upper class, solitary laboratory-oriented man'. While widespread stereotypes of scientists and physicists persist among the participants especially at the undergraduate level, they have the potential to change stereotypes by participating in science as who they are. This can be seen in the narratives of the participants that once they are more engaged in science, they create their own image of a scientist that is comparable to how they do science.  Gee suggests (2000, p. 86) that "there is a reciprocal relationship between a person and a social group and its core defining activity". The complexity of these relationships makes 'identity' alive, fluid and ever-changing. Accordingly, I argue that when women engage in science and constitute their science identities, they redefine the values and norms in science, they expand the definition of a 'scientist' and change the particular characteristic of a scientific community.

Popular media portrayal of scientists still often presents them in stereotypical ways – as "crazy-haired, old White boffin males, wearing lab coats, and probably glasses" (Archer et al., 2016, p. 60). In their narratives, women did not directly blame the media for not representing people from a diverse background in science. However, I interpreted some of their narratives closely linked with the stereotypical portrayal of scientists in media. Some of the participants drew upon examples from the TV show Big Bang Theory (nerdy geek masculinity), Nobel prizes (overwhelmingly white men), and NASA space stuff (a lot of men at desks and a lot of the big shots in space signs are men, middle-aged and White).

The findings revealed that in women's narratives the stereotypical image of a scientist was overwhelmingly masculine, however, it was not a sign of acceptance but a criticism of a dominant masculine culture of science. Some participants mentioned that the stereotypical image was replaced by the construction of a scientist themselves after they academically engaged in science. This shows that they added their understanding when they actively participate in scientific works. Some of them challenged the stereotypical image by giving an example from their appearance. Some of the participants compared a scientist with a physicist. Despite identifying the physicist as a 'man', they described a scientist as a 'person' saying that a biologist or a chemist can often be a woman. They categorized the branches of science as more masculine or as more feminine. One of the participants even categorized the subfields of physics according to a gender saying that a medical physicist can be a woman, but an energy physicist is always a man. She was the only woman who was studying in the energy field of physics at that time. Some of the participants positively accepted the 'nerd geek' stereotypical image as they were personally lean towards this label while some of them attributed a negative meaning to it saying that the label harms women as the 'nerd geek' image is viewed more masculine.

From their narratives, I understand that there are a variety of expressions and performances based on their lived experiences, their positioning, and the current situations of the participants. Even though the stereotypical scientists mostly tended to me White Western males in their narratives, they attempted to challenge it in an improvised way (at the time of the interview) in ways that constructed new positioning (See Chapter 5 for the participants' perception of themselves as scientists).

### 6.2.3 Doing gender

My theoretical perspective understands gender identity as discursively formed through performances and within wider power relations. Therefore, gender is regarded as something individuals ‘do’. From this perspective, “gender is actualized through a series of repetitive performances that constitute the illusion of a ‘proper,’ ‘natural,’ or ‘fixed’ gender (Archer, 2012, p. 970).

Analysis of the interview data suggests that what it means to be a woman is quite subjective and complicated. I realised through the interviews and my own life that ‘woman’ is shaped by various factors (e.g. gender role beliefs, norms, expressions, bodily acts, discourses, culture, experiences, anatomy) which makes it complicated to explore in every aspect. It is also very subjective as to how you do your gender (women, in this case) is only based on your specific standpoint, positioning, and experiences in life. ‘Women’ is also a collective name (labelling) that is shaped by society and redefined, transformed by individuals. As such a complicated label, I did not expect to reach a consensus about what it means to be a woman before the interviews. As one of the participants, Reese (BA) said: *“I am perfectly fine fitting within my description of a woman”* each of us can create our space (positioning) in defining, expressing, and acting our gender. Most of the women I interviewed described ‘woman’ according to their specific positionality, attitudes, and experiences. Through the interviews, I understand that ‘woman’ is a fluid and flexible term. As Dora (BA) said *“it is just like ‘love’ which is changeable over time”*

Gender is regarded as a spectrum, with masculinity on one side and femininity on the other. Analysis of participants’ narratives determined that the participants performed masculinities and femininities in various ways. In many narratives, the two were intertwined. The data suggest that some women interviewed enjoy performing bodily femininity, on the other hand, reject feminine characteristics or vice versa.

The role of gender in constituting the participants' science identities vary depending on their particular experiences, standpoints, and how they make sense of their gender. In Archer (2012)'s study which focuses on elementary school girls' science identity construction, it is stated that doing girl and doing science/clever identity is difficult to achieve as "science aspirations sit in an uneasy tension with femininity and must be continually carefully negotiated and defended against challenges from wider popular discourses which align science with masculinity" (p. 983). In my study, the performances/ practices of femininity and masculinity have been intertwined in most situations. For example, some of the participants enjoy performing femininity on the body but reject feminine features or vice versa. They have described themselves as 'feminine' dressed in 'womanly' clothing, but they have questioned and rejected feminine personality characteristics, as for them it may crash with their science identity. Some others have stated that they feel feminine inside but perform masculinity. One of the participants said she was proud to look girly and to be a scientist which is an unusual mix for her. Thus, I claim that there are multiple ways of performing femininity and masculinity within the context of science.

In certain cases, women have reported compromising the femininity in order to fit into science. In their own words, they 'have to make sacrifices for one or the other' (being a woman and a scientist). For example, they complained about the dress code in conferences and labs in which feminine clothing is deemed 'not professional' while 'typical men's outfit' is considered professional and appropriate. On one side, by adapting themselves to the conference and laboratory set-ups, they absorb and proceed on masculine norms, otherwise as Kathryn (PhD) said that if they have worn make-up and fancy dress, it is a matter of whether they are still respected and recognised as a scientist. On the other side, as they enjoy being a woman and a scientist which is described by Diane (BA) 'a strange combination' and they want to show that it is possible.

Similar to dressing up, make-up also described as a 'feminine' structure by the participants. The research by Banchefsky et al (2016, p. 106) suggest that "wearing make-up may be viewed as particularly incompatible with STEM careers because it suggests that a woman puts too much effort or time into her appearance". In this study, the women challenge the tension between looking feminine and doing science. As Annie (Ph.D.) puts it "I am a very feminine girl, also fantastic at science, but I don't feel I necessary to do either. I just do what I feel. And if it bothers someone, it bothers someone."

Some of the participants stated that women's traditional gender roles which crash women's science career make women 'multitasking' and 'strong'. In these narratives, (physical) science which is seen as 'masculine' and 'hard' domain (Francis et al., 2017) appears to clash with the traditional views of women's role in society. The participants used the identities of a woman as a 'wife' and 'mother' as examples of how to create an atmosphere where women fail to step into the roles of 'scientist'. In this situation, while women's gender and science identities were addressed as sometimes overlapping (and conflicting) across the narratives of the participants, they have also indicated that women are blessed with multitasking skills that enable them to be able to handle both identities (See Chapter 5, 'Negotiations of femininity in science,' for more information.)

For some participants their identity as 'young woman doing physics' makes them feel 'independent' and 'strong'. Their identification and engagement with science strengthen their gender identity and vice versa. In these narratives, I have noticed gender and science identities go hand in hand. And I feel that girls resist/challenge the tension between the subject position of a 'scientist' and the subject position of 'woman' by making a positive and reinforcing connection between their science and gender identities. In their case, being a 'woman' and a 'scientist' positively affects each other.

Regarding the role of gender in constituting a science identity, I did not notice any difference among women in terms of their age and level of study/academic position. From an intersectional perspective, women are double stereotyped in science when gender intersects with their other social/cultural identities. The participants have stated that if 'you are not white, man and western' you feel like you need to prove your scientific skills in order to be recognized as a scientist. "Once they are convinced by your work, they leave the stereotype behind" said Jill (PhD). This finding supports the argument made by Banchefsky et al. (2018) that the negative ideologies position the dominant subgroups—White men—as superior and normative, further marginalizing women and racial minorities. Thus, increasing the number of underrepresented groups in science is important in terms of eliminating negative ideologies and stereotypes towards minority groups.

Based on the finding of this section, I argue that the role of gender along with other social/cultural identities in constituting a science identity for women participated in this study varies depending on their experiences and how they make sense of their gender and other intersecting identities. Both during the interviews and analysis process, what I noticed first was their enthusiasm and passion for science. That is the core of their science identity constitution. The feeling of competence, accomplishment also positively contributed to a strong science identity development. In short, interest, enjoyment of doing science and a sense of competence have direct effects on science identity development, present engagement and intentions for future participation for the women.

To find out "How do female students and early career researchers in physics and physical sciences fields in higher education construct their science identity related to their gender identity?" I would assume that the science identities of women who participated in this study were constructed and shaped in a variety of ways. The role of their interest and passion for science from their early years and the feeling of competency positively affect their motivation to progress in the scientific field and to build a positive science identity. The women reported that they are discouraged by a stereotypical image of a scientist which is heavily white and male. However, they are also transforming it by actively participating in science as ‘who they are’.

As I have so far discussed, there were strong correlations among how the women do science, how they want to do science and their identification with science identity. Although widespread stereotypes of scientists and physicists persist among the participants, especially at the undergraduate level their performances do not reflect these stereotypes. Besides, developing an attachment to a scientific community has also a positive effect on building a science identity. Women who participated in this study points to the importance of networking, sharing, and collaboration in their ideal scientific work environments. This way, they would feel more integrated within their scientific community. However, even the feeling of less sense of belonging from a community perspective did not deter them doing science. Instead, it was regarded as a challenge on the path of become a scientist.

Finally, I would suggest that the content of the ‘being a scientist’ construction has shown an interplay of discourses of doing and enjoying science, enthusiasm, competency, participation to a larger scientific community, gender, and ethnicity within the everyday construction of science.

## 6.3 Research question II

- *What are the challenges faced by them arising out of incompatibility between gender-science identity?*

The analysis of the narratives revealed common challenges that they have faced on their path to being a scientist, developing a science identity, or progressing in a scientific career.

In my theoretical framework, identities are regarded as continuous development. The challenges that individuals experience along the way (of forming a science identity or developing it) can guide the individuals to the possible ways to how to get through them and how to come out of them stronger. Women's historical relationship with scientific careers has been full of slack of struggles (See Chapter 2). I believe, it is important to make the 'struggles' visible in order to break them.

The data from the interviews with 29 women emerged one main theme *Struggles* along with four subthemes: *Maternity and child-care, Low self-confidence and Imposter syndrome, Limited or lack of role model, Anxiety of proving.*

Interview findings reveal similar and complex experiences, expectations, and concern of women participated in the study concerning their current struggles with their science career trajectories. Experiences may vary depending on career/study stage and personal circumstances. However, I identified more similarities than differences in terms of the struggles they have experienced so far.

### 6.3.1 Struggles

One of the important issues emerging from the analysis was maternity and child-care. In general, the literature suggests that the most common challenge faced by academic mothers are the demanding nature of academic work, the ambiguity, and inconsistency of parental-leave policies, lack of funding for graduate students, tension between family and professional goals (Conley et. al, 2013; De Casanova, 2013).

The research by Goulden et al. (2009) found that once children or the plan for children exist women become more likely to move out of research compared to men. In this study, some participants talked about the fertility age and early career instability. They mentioned that women leave academic science careers at a certain stage when they cannot secure a tenure track position if they want to have a child. Whereas, for men, it is not the case. In this study, no empirical evidence is found as to how maternity affects their science identity in the long run, however, the analysis of the narratives show that it affects women’s future progression for academic science.

CohenMiller et al. (2019) described mothers in academia as ‘motherscholars’ who are in a complicated position, “being neither fully at home nor fully at work” (p. 638). Sutherland (2010) spoke of the social construction of the good mother ideology and its impact on the lives of mothers. She mentioned the uneasy tension between being a mother and being a Ph.D. student in terms of ‘devoting her time to care and to work at the same time’. She explained that when the academic programs do not accommodate motherhood, and the halls of academy reward those who work the longest and produce most, mama-guilt can go both ways.

Similarly, findings from a study of early-career academic mothers (Ward et al. 2012) demonstrated the guilt in the women felt about spending too little time with their children and too little time on their academic work. They found out that the women shoulder the primary responsibility of taking care of the children. In that study institutional context was found to be shaping the daily experience of being an academic and a mother.

In line with the previous studies, in this study, there was a general agreement on the huge impact of motherhood and caring responsibilities upon women’s science careers, especially in academia. Participants, regardless of their age, parenthood status, or level of study/ academic profession, often brought up maternity and parenthood-related issues during the interviews. It was interesting for me that even the youngest participants expressed concerns regarding the possibility of having children and the implication this may have for their future career progression. Even the youngest participants expressed their concerns regarding the possibility of having a child and the implications this could have on their potential career advancement, which I found interesting.

Especially Ph.D. and postdoctoral women commented on a lack of proper maternity schemes, ambiguous parental leave policies, and early career instability. They particularly mentioned the extremely challenging nature of being a mother/a parent and a researcher in academia. At that stage, the majority of participants discussed balancing caring/home responsibilities and being a good scientist. They mostly discussed issues such as pressure to publish for career progression, absence of paid-leave, returning to work after parental leave, temporary fixed-term contracts, and high commitment to the scientific project. Responses from the participants, by and large, reveal that science requires high commitment and dedication and women's traditional gender responsibilities may crash with a science identity and scientific career.

Gender, according to the participants, has a varied influence on their academic experience. For them, the identities of a scientist and a mother overlap resulting in a visible gendered issue that shapes both their science identity and their career progression. The picture gets more complicated when the burden of responsibility disproportionately falls on women's shoulders.

The participants' comments also indicate that gender role beliefs shape the perception of motherhood and parenthood. They often compared men and women in terms of their responsibilities by giving examples of from their life, colleagues, lecturers, and friends. I assume from their narratives that parenthood will be an additional barrier for women in physics and physical sciences disciplines, where women are already underrepresented at all stages, because women's responsibilities are also shaped by social norms and values that assign distinct gender roles to individuals. Some participants described it as a 'maternal instinct,' whereas others described it as 'natural.' All of them agreed that gender norms identified with women's pregnancy and care are traditionally and socially created, not intrinsic female characteristics.

Low level of self-confidence and imposter syndrome are two other critical topics that emerged from the study in relation to women's challenges. Women who participated in this study reported that they had always been good at mathematics and science from their early years which shows me that they have a high competence belief in science. However, a low level of self-confidence often was self-reported as a struggling issue for them especially for the participants at the undergraduate level. At the graduate and postdoctoral stage, lack of self-confidence was replaced by imposter syndrome.

One interesting finding during the interviews and analysis process was that despite the participants’ lower reported confidence in their science abilities, their actual science competence (e.g. in terms of their grades, performances, achievements, and academic progression) was high at that time.

The previous studies established a connection among self-confidence, achievement, and intention to remain in the discipline (Good et al., 2012; Cech et al., 2011; Hill et al., 2017) In this study, the women were already in science at all levels at the time of the interview and none of them indicated a lower sense of belonging or a possibility to change science career even if they complained about lack of/low self-confidence in science and imposter syndrome.

Their narratives reveal that their sense of confidence in their science abilities mostly comes from how people view women in science instead of how they view themselves. They became critical of their own skills because of the negative gender stereotypes around a scientist, lower representation of women in their research, work and study environment, and general attitudes of boys/men within their scientific community. They often referred to ‘boys are better at science and mathematics’ stereotype and men’s self-confidence in their scientific skills in general. The participants who studied single-sex schools in Ireland reported that they did not feel a low confidence issue in a secondary school as it was less competitive. However, at college, they became a minority by their gender and became shy about their skills and abilities. Another finding is that when they gained experience in science, they started to build stronger confidence in their scientific abilities. However, at Ph.D. and postdoctoral level, some participants talked about imposter syndrome.

As the literature suggests (Clance et al., 1978; Want et al., 2006), imposter syndrome is about an inability to accurately self-assess concerning performance. In an academic setting, previous research supports the claim that questioning their skills, expertise, and performance, comparisons with colleagues, competitive environment, internalizing success can foster feelings of impostor phenomenon. As for the study, as physics and physical sciences were widely described as ‘masculine’, ‘hard’, and ‘male-dominated’ fields by the participants, they ascribed a particular meaning to their gender as a ‘woman in science’ which may put extra efforts on their shoulders. The majority of them told me that after they realised they were in the minority because of their gender or other social/cultural identities, they sought to ‘prove their abilities’ and ‘justify their position’ in science (consciously or unconsciously).  For them, it stems from a sense of anxiety for them, which is another struggle I identified in their narratives.

Not all the participants experienced anxiety or self-doubt in a science context, but the majority, especially women at the early level reported that they tried to confirm their ‘place’ within their scientific community, research group, or class by working harder than their peers. Freedman’s et al. (2018) found that women’s feelings of doubt or anxiety in STEM classes may stem from the difficulty of the task or fear of confirming a negative stereotype. From the analysis of the narratives, I noticed that the feeling of anxiety arose not only from confirming gender stereotypes and bias and the difficulty of the task which is consistent with Freedman’s (et al.) study, but also the low representation of women in their classes or their research group, their minority background, and low self-confidence. Participants at higher academic levels, such as Ph.D. and postdoctoral, had already established their position in their field, so their anxiety levels were lower. However, Ph.D. and postdoctoral positions are strongly competitive and heavily male-dominated when a researcher advances in their careers. Because of maternity leave (fewer publications), a lack of role models (in senior positions), and a lack of equal credit for women (in conferences, the media depiction of scientist, science awards, work settings, discoveries and inventions) postdoctoral researchers found it difficult to compete with men in their disciplinary field.

The study found that women expect to be seen, known, and heard at the undergraduate level. The most common phrase the participants used were: ‘I want people to see me’, ‘I want to make my presence known’ and ‘I want to show that girls can do physics’. doubt. If women are stereotypically seen as unable to excel in science and mathematics due to their ‘female’ characteristics their emotional reactions to struggling in a science class are likely to be attributed to those internal characteristics (Freedman et al., 2018) Being aware of anxiety and its causes, according to this argument, contributes to working harder and proving one's progress as a ‘woman’ and a ‘scientist.’ Thus, in this study, anxiety is not seen as a negative factor that drives women away from research, but rather as a motivator in certain cases. However, no empirical data were found regarding the anxiety level of the participants.

One of the difficulties that the women in this sample faced was a lack of female role models. It was notable that the concept of the ‘female role model’ was mentioned by the participants as an important factor to develop a stronger science identification at all levels of academic science.

Hill et al. (2010) have found that exposing girls to successful female role models can help counter negative stereotypes because girls see that people like them can be successful in the field stereotype threat can be managed and overcome. The narratives of the participants were in line with this statement. It was often mentioned by the participants that seeing people 'who look like them' which means 'someone you can aspire to achieve something, same-gender group and similar cultural/social background' within their scientific community could be empowering for them. The narratives revealed that their identification with a role model involved personal connections (e.g. lecturer, researcher, professor) rather than someone with no interaction.

My answer to the research question "*What are the challenges faced by them arising out of incompatibility between gender-science identity?"* is maternity and care, low self-confidence and imposter syndrome, limited or lack of role model, and anxiety of proving. The women who participated in this study were greater awareness of gender stereotypes and inequality in science. The struggles they reported mostly were in relevance to women's gender identity. I have concluded that the combination of negative gender stereotypes and women's lower representation in their disciplinary area resulted in a high level of gender awareness among women which consequently heightens the awareness of the struggles they experienced in their research and study place. In line with prior research (Van Veelen et al., 2019) numerical and normative male dominance in science make women's gender category highly salient. In this study, I have concluded that gender awareness of women brings about understanding and identifying their struggles and developing a coping strategy rather than acceptance.

The struggles that the participants identified created both instinctive and extrinsic barriers for them to overcome. For example, majority of the participants mentioned lack of proper maternity/parental scheme, instability of early-career researchers and numerical under-representation of women at top positions within their institutions. These extrinsic obstacles resulted them in questioning academic career advancement in science. However, none of them claimed that they would end their science career fully. They mentioned a lack of self-confidence and imposter syndrome as intrinsic barriers that they attempted to overcome, but these were not identified as roadblocks to their scientific advancement.

The common coping strategies were often at the individual level and included sharing it with peers and colleagues and making it visible, building self-confidence, self-motivation, hard work and dedication. They were more driven by intrinsic motivators such as interest, pleasure of doing science, satisfaction and feeling of achievement than extrinsic factors at the work/study place such as institutional support and compliment from scientific others.

The participants developed resilience to overcome the struggles they have faced. At individual level their passion for science has encouraged them to advance in the field. It shows that the participants often depended on themselves to face science and gender related challenges. In some cases, resilience depended on external support (e.g. Mia's funding [Science Foundation Ireland] enabled her to take a maternity leave; the participants' faculty arranged women's support and networking groups). From an international perspective, minority underrepresented participants (in terms of ethnicity and religious beliefs) reported feeling of isolation in their scientific community due to pervasiveness white western male culture. These participants frequently discussed their high level of interest, dedication and academic self-confidence to persist in science. Their resiliency was attributed to their instinctive motivation.

In general, the participants expressed a desire to demonstrate to others, including themselves, that they are successful in science. This encouraged them to persevere in science despite the struggles they encountered along the way.

## 6.4 Research question III

- *What is the role of the feminist movement on women's science identity development?*

The findings for the research question above centred on the attitudes of women towards the feminist movement in science, feminist identification, and how the movement shapes their science identity development. The analysis of the narratives emerged two themes: 1) visibility and women's network, 2) the discourse on 'women in science'.

### 6.4.1 Visibility and women's network

In response to the above question, this research suggests that the feminist movement's equality and visibility practices place a strong emphasis on women's agency in science. Even though some of the women who participated in the interview did not explicitly mention feminism, they all stated that they support equality, diversity, and equal representation in science. Some participants openly identified as feminists, while others avoided feminism due to its negative connotations. The current study discovered that women's attitudes toward feminism were not differentiated by their age, social/cultural background, educational level, or academic position.

Based on the data, I concluded that those who identified as feminists were active members of 'women in science' organizations and were concerned about issues such as sexuality, gender roles, gender norms, and equal occupational opportunities even outside of science fields. My findings show that participants support feminist goals whether or not they identify as feminists (e.g. equal representation, eliminating unconscious biases and stereotypes, support networks, female role models, awareness of the challenges faced by women in science, and promoting equal opportunities). In other words, participants who had a positive opinion of feminists and feminism were more likely to self-identify as feminists. This result appears consistent with prior research that has found this relationship (Liss et al. 2001; Reid et al., 2004).

Based on the analysis, I found that women self-identified as feminists or women who lived in a liberal feminist friend circle had smoother identification with the subject position of 'women in science' than women who stayed away from the 'feminist' labelling. Most of them stated that 'women in science' is a twofold identity politics. On the one hand, it provides a platform for women to speak up and increases visibility. On the other hand, it may shadow women's achievement by focusing too much on their gender rather than their profession. The 'woman in science' tagline, according to the participants, is good for public visibility, but it could also be seen as a 'easy way' to get to a certain point in science.

### 6.4.2 The discourse of 'women in science'

The findings also suggest that labelling oneself as 'woman in science' has real-life consequences. It shapes their image and their positioning within their scientific community, the way their colleagues respond to this image (e.g. some people may react to gender labelling). On the one hand, they said it connects them with other women in science, which is good for networking, sharing, and supporting each other. On the other hand, they commented that it may give women a 'self-doubt' because of the positive discrimination of women in science. Through my analysis, I have argued that women's science identity resides in a critical balance of conflicting discourses of being a 'woman' and a 'scientist'. For some of the participants 'women in science' labelling and feminist identification soothe the tension between their science and gender identity by allowing them to develop a more flexible image of 'scientist' and 'woman'. For some participants, the discourse of "woman in science" represents othering processes, as if 'woman' has a conflicting and separate relationship with 'scientist.' Thus, what it means to be a 'woman in science' is constantly reconstructed and redefined within the discursive practices of what it means to be a woman and what it means to be a scientist. Furthermore, during my discussions with the participants, I got the impression that when the term 'women in science' is used to draw attention to the low representation of women in science, the identity of women in science is strongly endorsed.

The findings reveal that identifying as a 'woman in science' and engaging in 'women in science groups' are two separate things. Women may feel more 'integrated' and 'represented' if they engage in certain groups or events, according to those who have done so. As previously mentioned, the participants by great majority mentioned the importance of sharing, supporting, and collaboration within their scientific community. During the interviews and analysis process, I have felt that ‘women in science’ groups can provide them a supportive network where they can share their experiences and learn from each other. During the interviews, I found that while all of the participants favor conscious raising and network building groups for women, some of them were hesitant to call them feminist groups because feminism may evoke a negative response in public.

The data suggest that the participants’ support for the feminist movement can be viewed as a dynamic concept, not a static. Their support and participation depend on their past and current experiences, their struggles, turning points in their lives, their individual and collective consciousness, and how they conceptualize feminism at a certain point in their life.

Based on the analysis of the narratives, I have concluded that the participants’ understanding of ‘woman in science’ label that it raises awareness of the current problem of women's underrepresentation in science and increases visibility of women scientists. However, their identification with ‘women in science’ varies depending on their involvement with feminism and feminist politics, their interaction with feminist groups, their environment (if liberal) gender identity salience, and their past and current gendered experiences within their scientific community.

Science, according to the majority of the participants, requires commitment and hard work. Despite their devotion and hard work, women are not given equal credit in science, according to some participants. For instance, as Carol (postdoc) said, *we were taught in school that men made all of the greatest scientific discoveries. As a result, women's work must be outstanding in order to stand out and be noticed*. Similarly, Julianne (PhD) claimed that in a lecture, only male names are discussed when describing discoveries, also the picture of men doing physics are of men. She said *when people ask what I do, I always think I am a girl, and they don't expect me to do physics.* Majority of the participants also stated that boys think that they are better at science subjects than girls. Accordingly, there is cultural belief that boys are more suited to science as science demands certain personality traits such as objectivity, impartiality, detachment, etc which are considered as male features. However, it is not the science itself but how science and gender is viewed in the society that distinctively separate woman and man in terms of having scientific skills.

Haack (1992) stated science is a human institution, and it is surely not resistant to societal prejudices. In this study, the participants did not blame the nature of science of ignoring women's achievements, as seen by these examples above, but rather the culture of science of being male-centered.

Their identification with 'woman in science' label, according to them, brings attention to visibility of women doing science, as well as their achievements and contributions to the field by disrupting the masculine image of science. As one of the participants (Diane, BA) said *"just like you can't separate the person from the science, you can't separate the woman from the scientist entirely."*

In this section, I sought an answer to the research question "*What is the role of the feminist movement on women's science identity development*?" Previous studies which focused on women's science identity formation have not touched upon the role of feminist identity or the feminist movement on women's science identity development.

Several existing research (Yoder et al., 2010; Buschman et al, 1996; Toller et al., 2004) already examined the level of support of feminism on college women regardless of their academic disciplines and the impact of feminist labelling on their well-being and activism. My study specifically targeted at women in physical sciences to further explore the impact of the feminist movement and feminist identity on their science identity development.

Contrary to my expectation, the influence of the feminist movement in their (individual) science identification is not very significant. Instead, the movement has more a direct effect on their collective identity as ‘women scientists’ in terms of fostering visibility, representation, dispelling bias and negative stereotypes, recognizing and confronting gender discrimination and engagement strategies.

## 6.5 Conclusion

This chapter has evaluated the important findings in this study relating to each research question and positioned the findings relative to the literature as well as to the theoretical framework of this research. The focus of this chapter was the researcher’s interpretation of the participants’ voices that extensively analysed in the previous chapter.

# Chapter7 : Conclusion and Implication

## 7.1 Overview

To conclude this study, this chapter first presents general implications for Irish higher education faculties and practitioners in physical sciences fields. It is followed by future directions for research in the field. Finally, this chapter concludes with a concluding summary.

## 7.2 Implication

To address issues of equity, diversity, and identity in the field of physics and physical sciences, this study suggests that there is a need in Ireland to educate students about the culture of science at all levels in education. In this study, the particular focus is on third level physics and further physical sciences where the gender gap is the highest among all science disciplines in Ireland. Optional classes and seminars in science history and sociology, as well as feminist science studies, should be presented to undergraduate and graduate students, faculty members, and researchers in physics and physical sciences departments to raise awareness of gender norms, stereotypes, visibility, and representation issues in science. There are already 'women in STEM' organizations and special events for women in physics and science in Irish universities, but further participation could be promoted to welcome all genders.

The awareness of gender and diversity issues in all science disciplines, especially in physics and physical sciences should certainly be promoted through not only optional workshops held several times through a year, but also through departmental courses integrated into study modules. The women's narratives in this study revealed (in)visibility and (under)representation concerns of students and researchers in physics and physical sciences. The science education programmes in these academic fields should both train the students to be a scientist and to educate them about the culture of science.

A suggestion arising from this study could be that gender studies can be implemented in science studies at all levels in Ireland. The interdisciplinary perspective of gender studies can offer an alternative way of looking at the sciences and science education as a starting point to challenge the prevailing practices of doing science and research as well as to challenge the masculine norms and negative stereotypes in science.

In this study, one particular issue that arose was the instability of early academic career positions and vague policies around parental leave. Participants in this study talked about the cultural construction of motherhood, parenthood in academia, the tension between being a parent and a researcher in science as for them both need high commitment. Across participants, it was noted that role models (e.g. academic mothers) can provide examples for them to envision themselves as succeeding both as a parent and a researcher /scientist/academics. Uncertainty about their future personal and professional prospect leads to a leaky academic pipeline in the field of physics and physical sciences. Thus, building a network and mentoring is very important for women. Establishing a mentoring and networking programme can be facilitated by the departments and institutions.

The parental leave policies of the universities and funding agencies in Ireland are still lack of consistency for postdoctoral researchers and graduate students who are on a temporary fixed-term contract, which leads to a high level of insecurity and pressure, especially for women. Policies that effectively support family-work balance and paid parental leave should be available for postdoctoral researchers and full-time graduate students regardless of their funding agencies.

The findings of this study also highlight the importance of looking at the gender issue from an intersectional perspective. This study suggests that women have a variety of identities that develop both separately and interconnected. Evidence from this study pointed to a need for institutions of improving ways of more inviting environments for women from minority backgrounds. To address issues of racial, ethnic, religious, and gender bias present within science fields students and faculty members can complete meaningful bias training early in their educational journeys or careers. In this study, participants from minority backgrounds stated that their knowledge and skills are underestimated as if they were ‘less educated’. To address these concerns, institutions should implement inclusion-based and equity initiatives, training, and programmes targeting the faculty pedagogy in the field of physics and physical sciences.

Due to a limited amount of research on women’s science identity development in physics and physical sciences in higher education, an in-depth semi-structured interview method was utilized to understand their lived experiences, thoughts, and views. Especially in Ireland where this research took place, there has been no study done to specifically target women from undergraduate to postdoctoral level in physics and physical sciences fields in Irish universities.

Future studies could replicate this study to examine women’s science identity development by paying greater attention to a wider range of institutional contexts (e.g. type, size, geographic) and by including women from a wider variety of social/cultural background. Future research can also focus on longitudinal models of understanding science identity development, to understand how the concept of science identity might change over time.

Future studies can also look at similarities or differences in women’s lived experiences, their science identification, and science identity development across various subdisciplines of physical sciences and physics. There are no empirical studies to date in Ireland which looks at how interdisciplinary science identities might form within third level physics or physical sciences context.

Research examining the science identity development of women and shedding light on their lived experiences at third level science courses and research could be useful for departments, institutions as well as the Department of Education and Skills in Ireland to reach balanced participation in science disciplines across the nation. It could also be useful for girls considering a physical science major at college and women considering a science career in academia. These experiences could hold important details about creating an academic culture for science disciplines that embrace diversity and implement gender equality and inclusion in their policies.

## 7.3 Conclusion

This study has explored the science identity development of women from undergraduate to postdoctoral levels in physics and physical sciences fields in four Dublin universities through feminist, intersectional, and queer perspectives. The attention was given to their lived experiences, their self-identification, and engagement with science, their struggles, the role of gender, and other intersecting social identities on shaping science identity, and how they view the feminist movement in science and its influence on their science identity formation.

For the theoretical frame of the thesis, I discussed how feminist, intersectional, and queer theory helped me situate my analysis and motivated me during the production of each phase of this analysis, from designing the research questions to conducting the interviews, from examining the narratives to interpreting and debating them

An important focus of this study has been ‘gender’. I aimed to see how women’s gender identity (both individual and collective identities of women) functions in developing their science identities. First, this study originated from women’s lower participation and representation in the third level physics and physical sciences in Ireland where this study took place. Then, after reading about physical science and gender in the literature, I realised this was a global problem.

I simultaneously explored women’s doing of science and doing of gender through their narratives. I particularly looked at how they view their gender and science identities as well as how these two identities affect each other. Through investigating women's science and gender identity development I identified discursive fields, performances, and power structures behind them. My attention shifted to what makes 'woman' and a 'scientist' and how other intersection identities influence this process. This provided me a richer, deeper, and complex investigation of women's identity development.

Power structures behind identity construction deserve further attention which I realised that I did not pay attention to as much as I would have wished during the analysis process. How power functions in and between the intersecting identities of women and how power relations are embedded in the culture of science and the constitution of science identity can be further explored in a future study.

Even though women were influenced by the dominant idea of physics and physical sciences as being 'white' and 'masculine' they also challenged the dominant system of science identity by transforming it and blurring the boundaries of *what and who a scientist is.* The process of constructing a science identity may be stressful because science identity is not always compatible with 'women'. I noticed that women often defied the 'male image of a scientist' by attempting to blur the distinction between scientist and woman in their everyday experiences. Their struggles and challenges to the masculine structure of science are both individual and collective. They want to 'exist' and become 'visible' as who they are. They also use conferences, 'women in science' groups, and local gatherings to network, collaborate, and share their experiences. It shows that their 'science identities' are on-going process and are linked to other particular identities, individuals, and the culture and practice of science.

Understanding the development of women's science identities contributes to a broader perspective about how to provide a more inclusive and flexible science culture for people who feel they don't fit in or are left outside of certain prevailing norms in the field. It also can allow seeking a way of challenging and changing the predominant culture and the prevailing norms in doing science.

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# APPENDIXES

## Appendix 1- Interview Questions

### A. Biographical background

1. Age
2. Earlier studies
3. Nationality / Country of origin
4. Parent's occupation
5. Work experience

### B. Identifying as a Scientist

1. When did you first become interested in being a scientist?
2. Did you have a mentor/ a role model before you chose a science major?
3. Do you see yourself as a scientist? Or on the way towards becoming a scientist? When did you start seeing yourself this way? Has this changed during your undergraduate, Master's/Ph.D? project?
4. Can you describe a typical scientist? Do you feel you fit in this description?
5. What kind of personality or intellectual traits are necessary to succeed in your field?
6. Do science identities differ by gender? If so, how do they differ?
7. Is being a scientist an important part of your self-image?
8. Do you think seeing other people who look like you/ share the same cultural identity within your field reinforces your science identity?

**C. Understanding Gender**

1. Is your gender an important identity for you? Why/why not?
2. How do you identify your gender?
3. What does it mean to identify as an X (woman)?
4. Would you say the gender is fixed? Has it changed over time?
5. What was the first recognition of your own gender?
6. Does gender matter to you in doing science?
7. Do you ever feel you have been judged according to stereotypes? If yes, does it have something to do with being a woman in your field?
8.

**D. Struggles and Challenges**

1. How do you experience being a woman in your field?
2. How well integrated do you feel in your department? How well do you feel you fit in?
3. Do you think you have worked/working harder than your peers to be recognized as a scientist due to your gender, race, ethnicity, educational background, etc?
4. Does seeing more women in your field/department/lab/class affect your performance?
5. Do you think it (their specific major) is still a male-dominated field? If so, have you ever experienced any personal or professional conflicts participating in your academic domain?

**General Questions:**

1. What do you think about the feminist movement and recent political & social campaigns aimed specifically at women in science? Do you think these campaigns are

necessary /important in terms of increasing diversity in science fields?

2. What do you think about the leaky pipeline in science?
3. Do you believe the science community in your department is inclusive?
4. Do you think science has a gender issue?
5. Do you think science has a diversity issue?

**More Questions to Postdoctoral Researchers**

1. Do you think higher positions are accessible to all genders? Why? Why not?
2. Do you think diversity help to produce stronger research?
3. Is positive discrimination beneficial? What do you think of the positive discrimination of women?

# Appendix 2- Ethical Approval

5/15/2020 My Grades – ET7259-A-Y-201819

My Learning Space Modul EBRU EREN elp

**ET7259-A-Y-201819 RESEARCH ETHICS** My Grades

## My Grades

All Graded Upcoming Submitted Order by: Last Activity

| ITEM | LAST ACTIVITY | GRADE |
|---|---|---|
| **Application Status**<br>View Description | Dec 21, 2018 4:25 PM<br>GRADED | **Approved** |
| **8-12-2018 Ethics Submission and Resubmission**<br>DUE: DEC 8, 2018<br>Assignment<br>View Rubric | Dec 21, 2018 2:46 PM<br>GRADED | **Approved** |

https://tcd.blackboard.com/webapps/bb-mygrades-BBLEARN/myGrades?course_id=_47535_1&stream_name=mygrades&is_stream=false 1/1

**Declaration by All Applicants:**

I have read and understood the School of Education's policy on ethics in educational research: http://www.tcd.ie/Education/research/ethics/and Trinity College Dublin's Policy on Good Research Practice:https://www.tcd.ie/research/dean/assets/pdf/TCD%20Good%20Research%20Practice%20Policies%20copy.pdf

I declare that the details provided reflect accurately my research proposal and I undertake to seek updated approval if substantive changes are proposed after this submission. I have consulted an authoritative set of educational research guidelines.

Applicant's Signature:

**Signed:** **Date** 19/11/2018

**Declaration by Supervisor (if applicable)**

I have read this application. I am satisfied that it is in line with the criteria set out by the School of Education Research Ethics Committee in their published Code of Practice and application form templates.

Supervisor's Signature:

**Signed:** Aidan [illegible] **Date** 6.12.2018.

In instances where supervisors feel that their specialised expertise may be important, information for the REC to take into account (e.g.in relation to researching highly sensitive areas such as trauma/abuse), please submit an additional page with any relevant information.

**Final Approval Signed-Off by a member of the Research Ethics Committee**

Signed: Date



Application Page 2

Approved 21/9/2018

## Appendix 3- Participant Consent Form

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

- I…………………………………… voluntarily agree to participate in this research study.

- I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

- I understand that I can withdraw permission to use data from my interview within two weeks after the interview, in which case the material will be deleted.

- I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.

- I understand that participation involves being interviewed by the researcher about the research topic which is mainly on gender and science.

- I understand that I will not benefit directly from participating in this research.

- I agree to my interview being audio-recorded.

- I understand that all information I provide for this study will be treated confidentially.

- I understand that data collection (interviews) will be carried out in a sensitive and non-stressful manner

- I understand that in any report on the results of this research my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.

- I understand that the audio recording made of this interview will be used for analysis and extracts from the interview will be used in the thesis.

- I understand that disguised extracts from my interview may be quoted in any conference presentation, report or journal article, published paper developed as a result of the research and for future publications.

- I understand that if I inform the researcher that myself or someone else is at risk of harm, they may have to report this to the relevant authorities - they will discuss this with me first but may be required to report with or without my permission.
-
- I understand that signed consent forms and original audio recordings will be stored, and password protected on the researcher's computer. It will also be stored on the researcher's Google Drive account provided by TCD. Only the researcher and the supervisor have access to data.
-
- I understand that a transcript of my interview in which all identifying information can be held for a period of up to twenty years for possible future publications.
-
- I understand that under freedom of information legalisation I am entitled to access the information I have provided at any time while it is in storage as specified above.
-
- I understand that I am free to contact Ebru Eren, the researcher, and Aidan Seery, the supervisor, to seek further clarification and information.
    -

Thank you for participating in my research project.

I believe the participant is giving informed consent to participate in this study

Signature of research participant
Date

-----------------------------------------
-------------------

Signature of researcher
Date

# Appendix 4 – Participant Information Sheet

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

## PARTICIPANT INFORMATION SHEET

**Title of Research Project:** Science and Gender Relations: The Development of 'Science Identity' of Female Students and Early Career Researchers in Physics and Physical Sciences in Higher Education

**Participation Information:** I am a Ph.D. researcher in the School of Education, Trinity College Dublin. As part of my work, I am carrying out 3-year research funded by Trinity College into the development of the 'science identity' of women in physics and physical sciences through the gender perspective. As a part of this study, I am conducting individual in-depth interviews with women from undergrads to postdoctoral fellows in physics and further physical sciences in TCD, UCD, DCU, and TUD. I am trying to find out how science identity develops and is performed over the years at each level of study and different career levels in academia.

My goal with this research project is to deeply understand women's self-perception and evaluation of their own science identity in relation to their gender, and find out how "science identity" of women in their early (academic) career years impact on belonging, performing, and sustaining in the science field

Participation in this research includes a face-to-face individual in-depth interview about women's views, beliefs, experiences, and attitudes regarding "doing science", and self-evaluation of their "science identity" which will take approximately 1 hour or less.

I can foresee no risks for your participation in the interview, beyond those experienced in everyday life. The information gathered will be treated with privacy and anonymity. No information regarding you will be revealed in the research. Information will be stored safely with access only available to the researcher and supervisor. The anonymised results from the interviews will be included in a thesis and may be discussed at conferences or published in a book or a journal. The researcher can also use the data for possible future publications up to twenty years.

**Researcher Contact Details:** Ebru Eren E-mail: erene@tcd.ie
**Supervisor Contact Details:** Dr. Aidan Seery E-mail: seerya@tcd.ie

# Appendix 5 – Google Form

6/19/2020 Interview participants recruitment form - Google Forms

Interview participants recruitment form

Questions Responses 41

Section 1 of 3

## Women & Science

For a PhD project entitled "Science and Gender Relations: The Development of 'Science Identity' of Female Students and Early Career Researchers in Physics and Physical Sciences in Higher Education" funded by the School of Education, Trinity College Dublin, I am looking for volunteers to take part in my study.

The target group : Female students (Undergraduate & Master's) and early career researchers (PhD & Postdoc) in the fields of physics and/or further physical sciences in Trinity College Dublin, Dublin City University, Technological University Dublin and University College Dublin

Participation in this research includes a face-to-face individual interview about your own views, beliefs, experiences and attitudes regarding “doing science”, and self-evaluation of your “science identity” which will take approximately 45 minutes. My goal with this research project is to deeply understand women’s self-perception and evaluation of their own science identity in relation to their gender, and find out how “science identity” of women in their early (academic) career years impact on belonging, performing and sustaining in science field.

*Participation is completely voluntary and your answers will be anonymous.
*This study has been approved by the Research Ethics Committee in Trinity College Dublin.

After section 1 Continue to next section

Section 2 of 3

https://docs.google.com/forms/d/1fOa1FVpSwI37BMzQm0NW3UyMV7v4mJLc1sj-lasxraA/edit 1/3

Description (optional)

Name *

First and last name

Short-answer text

Gender

Short-answer text

Email *

Short-answer text

Phone

Short-answer text

After section 2 Continue to next section

Section 3 of 3

## Academic details

Description (optional)

Short-answer text

Your field of study / research *

Short-answer text

Your academic level/degree *

- ◯ Bachelor's
- ◯ Master's
- ◯ Doctoral
- ◯ Post doctoral
- ◯ Other...

# Appendix 6 – Participant Recruitment Poster

WOMEN & SCIENCE

## PARTICIPANTS NEEDED

FOR A PhD RESEARCH PROJECT EXAMINING THE "SCIENCE IDENTITY" DEVELOPMENT OF FEMALE STUDENTS AND EARLY CAREER RESEARCHERS IN THE FIELD OF PHYSICAL SCIENCES

- Your participation is entirely **voluntary**
- It involves one 40 min. in-person **interview**

Your contribution is most welcome if you are a bachelor's, master's student or a PhD, postdoctoral researcher In the fields of **PHYSICS** and/or **PHYSICAL SCIENCES** in **TCD, UCD** or **DCU**

**My goal with this research project is to deeply understand women's self-perception and evaluation of their own science identity in relation to their gender, and find out how "science identity" of women in their early (academic) career years impact on belonging, performing and sustaining in science field.*

**To volunteer for this PhD research, please contact me at**

**erene@tcd.ie**

## Appendix 7 – Recruitment E-mails

Dear …

I hope this e-mail finds you well. I am a Ph.D. researcher in the School of Education, Trinity College of Dublin. I am conducting a research project funded by the School of Education, Trinity College Dublin, entitled "Science and Gender Relations: The Development of 'Science Identity' of Female Students and Early Career Researchers in Physics and Physical Sciences in Higher Education."

This research will take place in 4 research universities in Dublin: TCD, DCU, TU Dublin, and UCD. The target group is female students (undergraduate and master's) and early career researchers (Ph.D. and Postdoc.) in the fields of Physics and Physical Sciences.

I am looking for volunteers to take part in my study. Participation in this research includes a face-to-face individual interview about your views, beliefs, experiences, and attitudes regarding "doing science", and self-evaluation of your "science identity" which will take approximately 40 minutes. My goal with this research project is to deeply understand women's self-perception and evaluation of their own science identity in relation to their gender and find out how "science identity" of women in their early (academic) career years impact on belonging, performing, and sustaining in the science field.

Participation is completely voluntary, and your answers will be anonymous. Thank you for your interest. Please click on the link below to begin your participation.

I would appreciate if you could circulate this to departmental staff, research students, and undergrads who may be interested in women's representation and participation in science.

I would also appreciate if you could share the poster attached on your social media platform and include it as part of the email invite.

Many thanks,

Ebru Eren, Ph.D. Candidate
School of Education, Trinity College of Dublin
E-mail: erene@tcd.ie
Phone: 083 383 7037

# Appendix 8 – Personalized E-mail Example

Dear …

Thank you for your willingness to participate in the interview for my research entitled "Science and Gender Relations: The Development of 'Science Identity' of Female Students and Early Career Researchers in Physics and Physical Sciences in Higher Education. I am very happy to hear back from you.

The interview takes around 40-50 minutes and is very informal. I am simply trying to capture your perception and experience concerning being a female student and a scientist in the field of physics and physical sciences. I am also interested in knowing your ideas and thought about the feminist movement, gender equality, women's representation, and participation in science.

Your responses to the questions will be kept confidential. Your participation is voluntary. You do not have to answer any questions you do not want to answer. The interview will be tape-recorded. This is done for data analysis. The tape will be transcribed by me, the interviewer, and kept confidential in a password-protected computer. All individual identification will be removed from the hard copy of the transcript.

This study has been approved by the Research Ethics Committee in Trinity.

If you suggest a day and time that suits, I will arrange my schedule accordingly. If you are happy with a meeting on campus, there is a quiet room reserved for us in the Arts Building at Trinity College. If you know any other place, pub, or coffee shop which is comfortable for you, I am happy to meet there, too

Your contribution is valuable for helping me to understand the "science identity" development of female students in science through your individual experiences.

The findings could lead to a greater public understanding of physics and women's participation and contribution to this field.

For more information, please do not hesitate to contact me via phone & WhatsApp or email

I look forward to hearing from you soon.
Ebru
Contact details: 0833837037 erene@tcd.ie

Ebru Eren
Ph.D. researcher
School of Education, Trinity College Dublin

# Appendix 9 – Example of Interview Scripts

Researcher: So how can you describe a scientist to me? What does a scientist mean to you?

Participant: When I think I first thought of myself as a physicist when I was in third and fourth year of my bachelor's, and I am not sure whether, you know, how that affects how I would define a scientist, it is tough because my view of what a scientist is has changed so much. When I was a kid, I would have viewed a scientist as someone in a lab, someone building something and, and they were usually a man I was picturing. But now I picture a scientist as just someone who is like working away at a computer or trying to understand an issue for months on end and doing this really tiny piece of this much bigger problem but out of very specific expert level. I think that is just because you know what I am surrounded by, like you base this on your environment or your influences. I have been so involved with women in science groups and women in science events. I am an executive committee member of WITS Ireland and like doing so much work for them and going to so many events…

Commented [EE1]: physicist identity

Commented [EE2]: scientist (fluid)

Commented [EE3]: scientist-stereotypes (gendered)

Commented [EE4]: scientist-me

Commented [EE5]: role model (you become what you see)!!

Commented [EE6]: networking & sense of community & women in science

Commented [EE7]: networking & sense of community

Researcher: Do you think science has a gender issue?

Participant: Definitely. We have maternity leave problem. If you take care of your family, if you have a child at home, if you have other responsibilities at home, the number of journals that you publish goes down. That is one main thing that I feel. You always have to make your decision based on your child and family.

Commented [EE8]: maternity

Commented [EE9]: child-care

Commented [EE10]: struggle

Commented [EE11]: child-care- family/responsibility

Participant: If there is two people, I mean a couple, in science then the woman often takes time off to go and collect the baby from creche or collect the child from school It is something that is currently on my mind now, so it would never have crossed my mind up until very, very recently. The fact that I think the gender balance in PhDs for physics remains the same. In undergraduate and even in PhD, I think the gender balance is fairly static. It doesn't drop off, but it is after PhD level that the majority of women in science just drops off massively. And I think that is because women are thinking, well what if I want to have a family and if I have a postdoc position, am I going to get maternity leave or am I going to be able to take time off? Am I going to take a year off? And that is really, really hard. So that is actually something that I would consider going forward. And I think it would be something that would influence my decision. I think that is the place where there is the biggest discrimination against women because it is assumed that the woman will go and take the child, but also the woman might want to go and take the child and then might want to go back to their work place. That is a really hard thing to do. Where have you been in the last few years? And we have all these amazing discoveries, like where are your papers? Where are your publications? I think that is really very difficult. I was talking to a friend, a male friend, and he was saying maybe the only thing is compulsory paternity leave. So, if you are having a baby, you both have to take some time off with this child.

Commented [EE12]: child-care

Commented [EE13]: maternity- drop put

Commented [EE14]: child-care (family-work balance)?

Commented [EE15]: maternity (too much pressure)

Researcher: Can women and men take parental leave in PhD or postdoc in your faculty?

Participant: I think it will depend on where your funding comes from whether you can take some leave or not. And it depends on that your supervisor and it depends, I guess because there is no rule, then people can get taken advantage of or you know, your position might be gone or maybe you might have your position, but by the time you come back, science has moved on so much that it is hard to catch up and, and I think that would be something genuinely I would think about going forward.

Commented [EE16]: maternity

Researcher: Do you think you are well represented in your area as a woman?

Participant: I don't know. I honestly feel like a man can represent me just as well as a woman can because I grew up in a different country and went through everything. I have suppressed a lot of things and I have kind of had to get over things if you get me. I have feminist views and I have feminist ideas and I know that people around me have feminist ideas and views, but I just don't want to say it because of what feminism means nowadays. And the definition hasn't changed. But the definition in the public opinion has changed because of the radical people, the radical feminism, you know, and I would have a lot of male friends and you know as a woman in science, I feel like I have a lot of male kind of features and my motivation and my sense of humor, I feel like I am not a very girly girl and maybe that is why I fit physics so much because I am not that feminine if you understand. So naturally I tried to stay away from feminism and from the word feminism because of just if you just mentioned it, the conversation closes, you know, people don't want to listen to...

**Commented [EE17]:** feminism /feminist view (negative conocation)

**Commented [EE18]:** feminism

**Commented [EE19]:** masculine/feminine

**Commented [EE20]:** gender / women in science

**Commented [EE21]:** gender/ physics/feminine

**Commented [EE22]:** feminism (negative connocation)

Researcher: Do you feel that you are well-represented science as a woman?

Participant: I definitely know that we are underrepresented in science. I have gone through like a mental shift there and I would say in the last two years where up until that point I was extremely proud not wanting any help. When someone says like, oh, like you are a woman in science, I would just be like, I am a person in science, I didn't want any kind of word or let's not have a pizza evening just because, you know, you have boobs and you also do science. It really bothered me because it was kind of, it was putting the attention on your gender when you are just trying to be one of the scientists. I just didn't want to be labelled with my gender. Now as of recently I have had like more of a shift and this conversation has had so much in our office or in conferences by women in science. And it is only through talking to other people that I have kind of realized the amount that women previously have fought to get us to where we are and where I don't have to worry about it. And I have never realized that it was such a big deal. And we have to kind of continue fighting for the next generation so that we will never have this problem. you know, you kind of have to keep fighting just for the next generation so that it is a 50/50 balance, maybe not a 50/ 50 balance, more like a 50/50 opportunity to pursue what you want to do, whether that is physics or not

**Commented [EE23]:** sense of community (casual gathering of women doing science)

**Commented [EE24]:** women in science (gender attached)!! important

**Commented [EE25]:** gender &labelling& women science

**Commented [EE26]:** labelling (women in science?)

**Commented [EE27]:** gender/labelling

**Commented [EE28]:** women in science/ sense of community

**Commented [EE29]:** feminism/equality