How School Students' Science Identity is Influenced by Their Gender, Religion, and Ethnicity Through the Lens of Intersectionality

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Abstract

This research explores the impact of gender, religion, and ethnicity on school students' science identities through the lens of intersectionality. In this research, science identity focusses on identification and recognition as a science person, having an interest in science, competence in science, and having a career plan in science-related fields. Intersectionality helps illuminate the influences of gender, religion, and ethnicity on the science identity of students in this research. Additionally, the study examines how obligatory and voluntary identities influence one another and highlights intersections of power, values, norms, and experiences within school, family, and broader social contexts.

The research is a mixed-methods study, conducted in a secondary school in a London borough with Year 10 students and their science teachers. Data were collected from a questionnaire completed by 145 students, seven science teacher interviews, and five student interviews.

Some teachers believe gender does not affect science identity, while others note image issues among students. The impact of ethnicity on participants' science identity is related to the importance of being successful in science and having career plans in science-related fields, especially in medicine, dentistry, or engineering. Religion can influence the teaching of controversial topics like evolution, and teachers emphasise the importance of inclusive education. Religion also shapes students' science identities by influencing their career plans through cultural interpretations.

The percentage of students with a science identity is 21%. Among students who have a science identity, religion is more important to them. While gender biases and social norms can negatively affect students by making them feel excluded. The movement and unity of women have been and will continue to be inspiring and supportive for women and young women, helping them to develop and maintain their science identity and strengthen social acceptance in the field.

The study provides valuable insight into how individuals experience the complex influences of these factors in developing or maintaining their science identity.

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1 Chapter 1: Introduction to the Study

The main objective of this research was to understand how gender, religion, and ethnicity impact the science identity of students who may share similar experiences but also exhibit various differences. Another objective is to integrate science teachers' perspectives on science identity and its intersectionality with gender, religion, and ethnicity within the context of their own experiences and those of their students. Lastly, the study sought to explore the strategies science teachers can employ to support and encourage students who already have a science identity or show potential for developing a science identity.

I could start rationalising my research aim by saying that this research is based on social justice concerns, intersectionality of oppressions, or similar; however, my primary motivation for conducting this study is the fact that I have experienced how being a Muslim Turkish woman has impacted my life, especially being a science person, and my related career plans. I believe personally, and know academically, that I am not the only person experiencing the impact of gender, religion, and ethnicity on science identity development.

The values and components of my life that are based on my personal background influenced the development of my science identity, but not by explicit exclusion or obvious limitations on what I could do and achieve. The initial experiences of how my science identity was influenced by values and other social factors were not clear to me because the circumstances I faced were normal for many people, and I was never told that I could do certain things but not others. However, the acceptance of being successful in science was matched by the idea of being clever and being male; the only issue was that I was not aware of this at that time. For instance, when I could answer questions rapidly and sometimes without the use of a pen and paper, the criticism I received from a physics teacher at a tuition centre about my ability became significant in a strongly negative sense. On the other hand, this was not the same for my male classmates. This perhaps reflected the dominant stereotype about the male dominance in physics.

The university entrance process in Turkey is based on a national examination. Until I took the exam and started to think about which department I wanted to study in, I had received no specific advice or direction from my family or the people around me; I was only motivated by them to perform well in the exam. However, after the exam, I started to think about studying mechanical engineering or physics. Regrettably, mechanical engineering was not seen as appropriate for Turkish Muslim females, and my father discouraged me from studying mechanical engineering because it is a male-dominated field. Similarly, my aspiration to study physics at a prestigious university was not acceptable to my family and close acquaintances, as they believed that the university promotes political activism and secular perspectives that clash with my family's conservative background. The mentioned conflict between university ideology and my family's conservative background overshadowed the significance my family attributed to education and being successful, and as a result, I could not study mechanical engineering or physics.

Finally, after careful consideration, I decided to go to the education department, which was the best path for me, with the agreement of my parents. Fortunately, I chose the science education department, which aligns with my interest in science. This was the starting point for me to read about women's rights, and I started to develop my knowledge and advocate for women's rights and what women could do. However, there were times when a conflict arose between prioritising my parents' satisfaction and happiness and my personal desires. I find it difficult to explain why my parents' approval is so important to me, but this may be a deeply embedded cultural value or simply a personal conviction. However, I started questioning whether I should prioritise and care about what I want or satisfying my family. Although both are important to me, I found a way, through open communication, mutual understanding, and agreement, that allowed me to do what I wanted whilst maintaining strong relations with my family.

With the benefit of globalisation and the forms of communication I used, I have been supported in my decision to undertake postgraduate studies, obtain a master's and PhD degree, and work in academia. However, this decision engendered another challenge: my desire to obtain my master's and PhD degrees abroad. Despite the opposition of my family, this time I stood strong in my decision and prioritised my aspiration over what my family wants or thinks. Although my parents initially thought it was not a good idea for a woman in her early twenties to live a lonely life in a different country, they witnessed the evolving world and the emergence of independent and strong women. Consequently, as a result of globalisation, there has been an expansion of opportunities and an increasing number of women in STEM (Science, Technology, Engineering and Mathematics) fields. I am particularly proud of my sister, who shared a similar passion for pursuing her dreams in engineering and successfully achieved her goals. I am also grateful for my parents' understanding, even though sometimes they needed to accept situations that were contrary to their values, and for their support for my sister's scientific aspirations, largely influenced by my own demonstration of overcoming the obstacles encountered during my personal journey.

1.1 What Science is and How it is Conceptualised in This Research

Whilst stating my interest in conducting research about science identity, a brief introduction to science, including its nature, its role in social science, and science in STEM (Science, Technology, Engineering, and Mathematics) fields, is useful to conceptualise the framework of science. Science, according to the Cambridge Dictionary, is "knowledge from the careful study of the structure and behaviour of the physical world, especially by watching, measuring, and doing experiments, and the development of theories to describe the results of these activities."

Science can be classified into three main categories: natural sciences, social sciences and formal sciences (Chalmers, 2013; Löwe, 2002). Natural sciences cover biology, physics, and chemistry and their sub-subjects, whilst social sciences are related to psychology, economics, or sociology, and knowledge in social sciences produces itself and becomes part of studied systems (Chalmers, 2013). Formal sciences are mathematics and theoretical computer science (Löwe, 2002).

Science is a broad term and can basically be summarised as a "body of knowledge, method, and way of knowing" (Abell and Lederman, 2007, p. 833). This leads to an explanation of the nature of science, which is about underlying processes, the methods used to acquire knowledge, and the epistemology of science; the nature of science is related to scientific inquiry and the development of scientific knowledge. Moreover, according to Avraamidou and Schwartz (2021), scientific knowledge is shaped not only by the data collected and interpreted but also by the values, stereotypes, and perspectives of scientists themselves.

Furthermore, in academic and professional contexts, STEM has been studied and integrated into various complex research fields. Innovation and practical problem-solving skills are main focuses of STEM fields; therefore, the interconnectedness of these four main areas also extends its approach to various fields such as medicine (Martín-Páez *et al.*, 2019). For example, Breiner (2012) addresses the fact that an engineer may need well-developed scientific, technological, and mathematical knowledge, as well as complex thinking ability and transferable skills between these. In my research, the primary focus is not STEM fields; however, some sources and references contribute insights that could be useful in terms of understanding various matters because of the complex and connected nature of these fields.

In this research, the term 'science' primarily refers to the natural sciences – such as biology, physics and chemistry – because the research focuses on science identity within these fields. However, this does not mean that other types of science are disregarded. Insights from social sciences, for example, contribute to understanding identity formation and the broader societal context in which science education and careers develop.

1.2 Aims of Science Education in England

Science education is essential for enabling many countries to educate future scientists or people working in STEM fields. School-based science education represents the formal side of science learning. However, according to Avraamidou (2014a), science education should not be solely specified through school science education; scientific skills, attitudes, and aspirations could also be established by improving scientific knowledge in and outside of schools. There are various institutions and organisations that provide a broad spectrum of science-related activities which individuals could benefit from in various ways. In addition, multiple research studies have been conducted on science education, examining its purpose and coverage both in and out of school, and related organisations. For example, Archer *et al.* (2015) listed some of the settings outside the school context in which to learn about science and/or develop scientific information, such as designed spaces (e.g., science museums, zoos, aquaria), organised activities apart from science lessons (e.g., afterschool science clubs), and daily activities (e.g. doing experiments at home, repairing things, outside walk). Additionally, Mansfield and Reiss (2020) highlighted the importance of out-of-school science learning, which could occur in students' daily lives, but they also emphasised how school science education is important, referring to the increased amount of research and the values nations have attributed to school science.

Therefore, the informal side of science education or learning contexts should not be overlooked; however, because the current research was conducted in school settings, the main aims of science education in schools also need to be mentioned.

Given the emphasis on the importance of science and science education, the potential benefits of nations attracting and keeping people in science fields were highlighted by Stets *et al.* (2017). However, the vital role that science education plays is not solely a national matter. Other potential aims of science education mentioned by Mansfield and Reiss (2020, pp. 7–14) are the "supply of future scientists, science literacy, individual benefit, democracy, social justice or socio-political action, and criticality." These cited aims may be some of the main reasons for valuing science teaching and learning in educational settings. The Department of Education (2013) also underlined some of the principal objectives of science education; for example, students should be supported to understand and explain what and how is occurring, predict how things work and happen, analyse reasons, and be critical. In short, the main goals of science education in schools are for every student to learn essential scientific knowledge and methods and apply them in their lives both today and in the future.

Moreover, given that the main objective of this research is to understand how students' science identity is impacted by their gender, religion, and ethnicity, both in-school and out-of-school science education-related contexts were likely to be relevant. Therefore, being able to reach students and teachers simultaneously to elicit the shared or observed experiences of every participant and, to some extent, others who share the same environment was beneficial in enhancing data collection. That said, conducting research in school settings did not mean that any possible science activity or meaningful circumstances relevant to science identity would be ignored if they take place outside of school contexts. In this way, any influences related to gender, religion, and ethnicity on the science identity of students were the focus both in and out of school.

Although the importance of keeping people interested in science has been highlighted in numerous studies, as well as this one (Anderhag *et al*., 2016; Swarat *et al*., 2012; Blankenburg *et al.*, 2016; Jackson *et al.*, 2019; Kang *et al.*, 2019) , there have been and will be a large number of individuals who do not continue studying science subjects and pursue a career related to science for various reasons. Therefore, it is worth focusing on the science pipeline and the leaky science pipeline. To briefly clarify, the science pipeline refers to pursuing a science career, whilst the leaky science pipeline refers to stopping studying science and not pursuing a science-related career. More information and a discussion about the significance of some of the elements of influence in the science pipeline form the topic of the following section.

1.3 Science Pipeline

Science pipeline is a metaphor that highlights being persistent in studying science and remaining in science-related careers. Another concept related to the science pipeline is the 'leaky' science pipeline, which is mentioned by many scholars who focus on why some individuals, such as women and underrepresented groups discontinue their science studies or do not want to be in the fields of science (Adamuti-Trache and Zhang, 2022; Ceglie, 2011; Quinn and Cooc, 2015). With respect to the science pipeline, a few studies are analysed, and many similarities and differences about the science pipeline can be identified and thus summarised. Despite the studies being conducted with various groups of participants and focusing on diverse issues, consistency could be evident across all the research in the view that identity and identity development are important factors in the science pipeline, particularly in developing bonds and staying in the fields of science. For example, some of the main focuses on identity were examining the overlapping identities of women of colour who have STEM-related careers (Johnson *et al.*, 2011; Calabrese Barton *et al.*, 2013), the identity development process of middle school girls who have minority backgrounds (Calabrese Barton *et al.*, 2013), and high school students' construction of a science identity (Aschbacher *et al.*, 2010).

Overall, such studies have emphasised the challenges faced by individuals throughout the science pipeline. These include inadequate support in educational institutions and communities (Allen-Ramdial and Campbell, 2014), a lack of representation (Johnson *et al.*, 2011; Calabrese Barton *et al.*, 2013; Weeden *et al.*, 2020), and the persistent existence of gender, ethnicity, and social backgrounds (Archer and Francis, 2007). Ultimately, these studies stressed the need to attend to these matters and take action to address the circumstances and difficulties in the science pipeline. By doing so, individuals could be supported and maintained in STEM fields; such action could take place through practical research projects in educational institutions (Atkins *et al.*, 2020;

Estrada *et al.*, 2018; Goulden *et al.*, 2011) or by aiming to ensure equal access to science classes and activities for every individual (Archer and Francis, 2007).

Due to the overlapping elements of my research content and the science pipeline, I examined studies on science interest and science career plans and how these are influenced by the focal elements in my research, which are gender, religion, and ethnicity. My research is significant in that it explored the complicated impacts of gender, religion, and ethnicity on students' science identity by adopting an intersectional lens. Although existing resources have studied some related parts of these elements, science identity, and the science pipeline, there has been a notable gap with respect to the influences of gender, religion, ethnicity, and the intersection of these in science identity construction. Furthermore, by shedding light on the complicated dynamics of the aforementioned three elements and science identity through the lens of intersectionality, my research contributes to the advancement of science identity studies within role identity theory and the use of mixed-methods research for studying the science identity of students.

1.4 Study Purpose, Design, and Research Questions

This study primarily aimed to understand the impact of gender, religion, and ethnicity on students' science identity. First, it is important to discuss the conceptualisation of identity in this research and explain the theoretical framework that was adopted. In this regard, Gee's (2000) focus on identity conceptualising serves as a major reference. According to Gee, identity refers to how an individual recognises himself/herself as a specific type of person within a specific context. This perception may depend on time and situations, and it can also be unpredictable. Additionally, various elements, such as personal characteristics, cultural expectations, and environment, might play a role in individuals' identity development as well as the formation of their science identity. Therefore, elements of characteristics and values, gender, religion, and ethnicity are interconnected and overlap with the concept of science identity. The conceptualisation of science identity in the existing literature varies; for example, some scholars describe it as referring to how students identify themselves with science and are recognised as a science person by people around them (Carlone and Johnson, 2007; Archer *et al.*, 2010; Vincent-Ruz and Schunn, 2018). There are two sides to being a science person: one at a personal level, the other at a socio-environmental level (Aschbacher *et al.*, 2010); these two sides may refer to the identification and recognition of individuals.

The purpose of this research was to explore science identity construction at the individual level, as well as how students experience socio-environmental influences with a particular focus on their preferences and how they experience the effects of their gender, religion, and ethnicity. Additionally, the idea of voluntary and obligatory identities, which was conceptualised by Turner (1978) and also studied by Gallagher (2016), provides a nuanced understanding of science identity development in relation to valuable elements in students' lives. Whilst these factors — comprising gender, religion, and ethnicity — were taken into account to generate a detailed understanding of science identity, as well as how each relates to it, the use of an intersectional lens illuminated specific concerns about how all these elements collectively influenced students' science identity.

This research was designed as a mixed-methods study to be conducted in secondary schools in London. The participants comprised Year 10 students and their science teachers. To answer the main research question, that is, how religion, gender, and ethnicity influence the science identity of students, students were asked questions about their demographic background, gender, religion, and science identity; data were gathered from students through questionnaires and individual interviews. In addition, their science teachers were interviewed about their own experiences and thoughts about students' science identities. Aligned with the established aims of the study, the study sought to answer the following questions:

1. From the perspectives of students, how are students' science identities impacted by gender, religion, and ethnicity through the lens of intersectionality?
2. Within the obligatory and voluntary identity contexts, how do students experience the impacts of gender, religion, and ethnicity on their science identities?
3. How do science teachers perceive the impacts of gender, religion and ethnicity on their science identity and their students' science identity through the lens of intersectionality?

This research aimed to shed light on how ethnicity, gender, and religion affect students' science identity through the lens of intersectionality framework whilst supporting the larger goals of diversity in educational settings and of learning and teaching outcomes in science education.

1.5 Chapters of Thesis

Chapter 1 provided a concise overview of the key aspects of the study. In addition, it delineated the justification and motivation for the research emphasis, as well as the aims, research objectives, and research questions central to this study on scientific education in England. The content of subsequent chapters is as follows:

Chapter 2 reviews the literature on science identity as well as the influence of gender, religion, and ethnicity on the science identity of students. The literature review is divided into themes. The theme of ‘Identity’ provides information on the concept of identity, identity development, obligatory and voluntary identity, and the term ‘science identity’. The theme of ‘Intersectionality’ provides a historical background and information on an intersectionality framework and related components such as gender, race/ethnicity, and religion. The theme, ‘How Gender, Religious, and Ethnic Identities Were Conceptualised in This’, explains the conceptualisation of these terms and discusses their influences on the science identity of students.

Chapter 3 focuses on the methods and methodology employed and consists of four sub-topics. First, the research paradigm provides information about the ontology, epistemology, and paradigm adopted in this research. The next part, Mixed-methods Research, presents information about what mixed-methods research is, what kind of data were collected, and how data collection instruments were designed. The third part, Pilot Study, gives information about why this section is written, how the pilot study was designed and conducted, and the outcomes of the pilot study for each research data collection instrument. The final part, Main Study Data Collection, provides information and details about the main approaches to data collection.

Chapter 4 presents the findings of the study, which are organised into several themes derived from qualitative interviews with science teachers and students, as well as quantitative data collected from students. The chapter is divided into three main parts. The first part analyses the quantitative data collected from students, examining questions related to gender, ethnicity, religion, science interest, self-identification as a science person, and science career plans. The second part presents the findings from interviews with students, examining their perspectives on being a science person, gender and science, religion and science, ethnicity and science, parents' discussions about gender, religion, ethnicity, and science, and the intersectionality of gender, religion, ethnicity, and science identity. The last part focuses on science teacher interviews and explores themes such as understanding what constitutes a "science person" from the perspective of science teachers, gender and science, religion and science, ethnicity and science, culture and science, and the intersectionality of gender, religion, ethnicity, and science identity. In so doing, Chapter 4 provides a comprehensive exploration of the various factors influencing individuals' perceptions of science and their identities as science persons.

Chapter 5 offers an analysis and discussion of the findings in relation to the existing body of literature. The design of Chapter 5 allows to answer each research questions specifically. However, there is no clear grouping in the discussion chapter because of the adopted mixed-methods research design and supporting or explanatory information is used across the entire chapter to provide an in-depth understanding.

Chapter 6 is the concluding section which first provides a summary of the outstanding findings and the discussion parts presented in this chapter. In so doing, important findings that could potentially contribute to the literature are also highlighted. The chapter ends by considering the limitations of this study and making recommendations for further research.

2 Chapter 2: Literature Review

2.1 Theoretical Framework

2.1.1 What is Identity and How is it Conceptualised in This Research?

The term identity has numerous definitions in the literature. The complexity involved in the production of an identity is defined and conceptualised in different ways and with various theories. When discussing identity, conceptualising identity and distinguishing identity theories may be challenging. I could start with the classical studies that have given rise to identity theories, such as those by Erikson, or Vygotsky; or I could highlight multiple theories developed by famous scholars which are important in psychology, sociology, and other fields and studies related to identity development. For example, major elements of Erikson's (1959) theory of identity emphasise the dynamic nature of identity formation and the significance of adolescence as a time of exploration and self-discovery, as well as the cultural forces that impact this process. Bradbury and Miller (2010) and Burkitt (2011) highlighted a key aspect of Vygotsky's identity development theory, which suggests that identity is shaped by cultural-historical contexts, social interactions, and language, and is an interpretive process influenced by cultural and social factors.

Regarding specific identity-related theories, there are many more that could be discussed but Identity Theory may be the most significant one to highlight in this research. Identity Theory has roots in sociological perspectives and conceptualises how people define themselves in their society by examining the meaning of the roles they adopt, their group memberships, and their personalities (Burke and Stets, 2009). Additionally, it investigates how multiple identities of individuals intersect, influence others' behaviours, thoughts, and feelings, and the connection between individuals and broader societal contexts. Therefore, in this research, it is essential to clarify the conceptualisation of identity, along with related concepts such as intersectionality, gender, religion, and ethnicity. Due to the complexity of the terms, a detailed discussion of each term and its relation to others is not possible in this thesis; however, specific importance will be attributed as much as possible to science identity, intersectionality, gender, religion, and ethnic identities. Therefore, the section on identity will be brief in order to fully describe the adopted conceptualisation of what identity means.

As indicated previously, there is no unitary definition that covers what identity is and every factor that impacts identity construction. Therefore, when discussing identity, it is essential to elucidate its complex nature and consider multiple perspectives and frameworks that can help clarify different aspects of identity formation and expression that can be used in this research. For instance, identity might change depending on the context; for example, how a person defines himself/herself at work may or may not be how the person defines himself/herself in other settings (Trujillo and Tanner, 2014). Additionally, Nasir and Saxe (2003) stated that individuals may not develop identities isolated from the cultural environment that potentially impacts social interactions. Furthermore, Renninger (2009) asserted that a person could identify herself/himself with reference to a group/groups or certain content.

Gee (2000) posited one approximation for identity that forms part of this enormous body of literature. The dynamic nature of identities is emphasised by Gee (2000), who argues that identity can be constantly reimagined and reconstructed; and this dynamic nature makes the identities of individuals uncertain and unstable, influenced by various factors such as time, occasion, and circumstances. Gee's approach to identity is based on the actions and interactions of individuals, as well as simultaneously being recognised as a 'kind of person' or 'kinds' (p. 99). While Gee's identity approach shares ideas with identity theory regarding the social construction of identities and multiplicity of identities, the Gee's (2000) conceptualisation specifically focuses on Discourses – with a capital D – because the 'discourse' refers to the use of language in written and spoken communication, while 'Discourse' refers to a broader concept, such as being part of life and the world by having values, acting, thinking, feeling, being identified as a '(certain) kind of person', not just through language. These Discourses refer to how individuals experience being participants of social life, intertwined with language, behaviours, values, beliefs and socials norms and practices (Gee, 2000). The importance of Gee's identity approach in this research is that identity construction is influenced by intersections of mentioned factors. Therefore, as intended in my research, this approach will help in understanding how the intersectionality of various factors – gender, religion, and ethnicity – impacts the science identity of students.

Identity can be shaped by our environment, interactions with others, and the historical background of communities (Rubin, 2007; Avraamidou, 2016). According to Price and McNeill (2013), cultural components and artefacts, such as tools and symbols, also influence identity construction; the meanings individuals gain through lived experiences and future experiences can change identity production. Therefore, the effects of culture, environment, and myriad other components in individuals' lives may impact students' experiences and, consequently, their identities. Therefore, for my research I defined identity – as well as science identity – as multidimensional, relational, and impacted by culture and social institutions. As the research focused on the impacts of gender, religion, and ethnicity on science identity, these factors were considered influencing elements.

As mentioned above, culture, environment, and various values may influence identity development; however, their effects may vary among individuals. For example, in terms of culture, Phillips (2010) posited the inspiring idea that a person could wear her/his culture. Moreover, the culture could be worn heavily by people who are strongly connected to their cultural backgrounds, or they could wear their culture more lightly if they are less involved. The idea behind this could be that values are internalised strongly or lightly, affecting the degree to which the individual can easily put aside the values of their culture. Furthermore, from the perspective of culture and identity, a lightly internalised culture may have less influence on identity construction when compared to a strongly internalised culture. Phillips's idea is a pointer to Gallagher's (2016) research on voluntary and obligatory identity, and their conceptualisation, which are explained later in this chapter.

Individuals construct multiple identities throughout their lifespan, and at any juncture in time, possibilities exist to activate different kinds of identities. For instance, a person could be a scientist in one context, a friend in another, a mother, a tenant, and so on. When the relevant identities are verified, each is activated in a certain situation to control meaning and resources (Burke and Stets, 2009). However, there are a number of points that require further explanation. For example, the idea of multiple identities and its ties to social structure could be explained by role theory. However, what is confusing in role theory is that it is not always clear that it has anything to do with 'people'; for example, roles could be related to other roles, or expectational roles. Also, the conceptualising of identities is based on verification and becoming activated, which means there should be a need for a certain kind of identity, and that an individual's identity should be recognised and validated by the people around them. Therefore, it is possible for an individual to switch between identities or represent more than one identity at once when it is necessary. For example, an engineer could reflect her/his engineer identity on site, but if she/he is a postgraduate student, she/he needs to activate a student identity at university. At the same time, the friend or parent identity may also be required in those circumstances.

In summary, identity is difficult to study because of the complexities involved in defining who we really are and how we come to see ourselves as certain types of people (Brickhouse, 2001; Aschbacher *et al.*, 2010). Identity scholars who study social roles have asserted that these roles have an impact on individuals' everyday lives and self-concepts (Burke, 1991; Gallagher, 2016). According to Gee (2000), identity is socially constructed by various dimensions, and this insight helped me to conceptualise science identity. Given the complex, multidimensional and unstable nature of identity and the fact that we have various identities at different times and places, science identity could be one of the identities that are developed by individuals. However, the nature of science identity, as evident within the process of constructing such an identity, may be influenced by various elements such as being interested in science, the compatibility of values – such as gender, religion and ethnicity – with science, or having science career aspirations. Having defined what is meant by science identity, it is important to further explore its conceptualisation and the influences of gender, religion, and ethnicity on its development as the focus of my research.

2.1.2 Science Identity

Identity may be context-specific, meaning that people define themselves differently at work, school, home, or any other place. Identity construction is an ongoing process, and the process of constructing a science identity can either be supported or destabilised by how individuals perceive themselves (Robinson *et al.*, 2018). For instance, as Avraamidou (2019a) highlighted, certain norms and rules may be influential in forming the science identities of students in terms of what and who are valued, especially with regard to school which is where students spend much of their time. Notably, school functions as a whole entity, but with diverse structures which might be crucial factors impacting the social construction of identities. Moreover, these contexts have external inputs such as students and teachers, as well as other staff, gender identity, race, ethnicity, sexuality, and ability.

Ultimately, it might be useful to employ a framework that not only highlights performance and recognition in science but is also better able to conceptualise culture – a framework that emphasises the ways in which socially constructed identities and experiences intersect and impact science identity production. For example, Robinson *et al.* (2018) reported that individuals' attitudes towards science and competency in science are a significant predictor of having a robust science identity. Science identity is based not only on an individual's desire to become a science person, but also on the socialisation of individuals within scientific communities, which results of being part of science practices and/or using science language (Brown, 2004; Vincent-Ruz and Schunn, 2018). This socialisation provides individuals with an opportunity to see themselves in the field. Science identity construction has been conceptualised in many different ways. For instance, scholars have highlighted different key points related to science identity, arguing that it is: built by consistent extrinsic and intrinsic attitudinal factors (Aschbacher *et al.*, 2010); based on a match between school science and real science (Archer *et al.*, 2010); a discovery orientation that includes ways of thinking, feeling and acting when immersed in a field of science that motivates one to persevere in sense-making activities (Hill *et al.*, 2017; Jaber and Hammer, 2016).

Moreover, Stets *et al*. (2017) pinpointed characteristics of science identity linked to identification with science and the verification of such identification, as well as referring to the importance of science identity and its significance in having a science-related job. Stets *et al.* (2017) presented an alternative view of science identity which focuses on individuals' self-perception; specifically, whether they identify themselves as science persons and act accordingly. Although various conceptualisations of science identity can be found in the literature, Vincent-Ruz and Schunn (2018) indicated that such conceptualisation is inconsistent, which means there is no one definition or conceptualisation to draw upon.

Additionally, Jackson *et al.* (2016) conducted quantitative research to measure the strength of students' identification and recognition with science or being a science person, and how identification and recognition influence their science identity. A notable finding from this research was that social recognition and positive appraisal significantly influenced the science identity of women with low or moderate existing science identity but had little effect on those with a high science identity.

The contribution of Jackson *et al.*'s (2016) study regarding the influences of identification, social recognition and positive appraisal is significant. However, the aim of the research, which was to examine the effects of social recognition and appraisal, which meant that it could have overlooked certain personal characteristics, as well as socio-environmental impacts. For example, does recognition by others and positive appraisal have similar effects on women compared with men, on Muslim believers compared with Christian believers, or on black persons compared with white persons? And are these factors equally influential on, for example, black Muslim women in terms of science identity development? This could have been the focus of their research because of the feasible research design and their research interests. Nevertheless, despite the numerous factors which potentially affect science identity, each piece of research makes a nuanced contribution to the existing science identity literature.

However, with regard to science identity – which is basically based on identity concepts (as explained previously) – as the concept-specific focus of the study, it is also essential to highlight characteristics such as science interest, competence in science and career aspiration because these could be characteristics aligned with having a science identity in this research. Numerous studies have already focused on identification-recognition, interest in science, using science in various contexts, and competence in science. Therefore, I need to address the conceptualisation of science identity adopted in this research. After careful consideration and reviewing the literature on complex and multidimensional identity construction and science identity development, identification and recognition are the important concepts related to identity and science identity.

Interest is one of the most frequently studied components in science-related research (Blankenburg *et al.,* 2016; Christidou, 2011; Durik, 2015; Hidi and Renninger, 2020; Jackson *et al.*, 2019; Kang *et al.*, 2019; Maltese and Tai, 2010; Renninger, 2009). "Interest is defined as both a psychological state and as a predisposition to reengage content over time" (Renninger, 2009, p.106). According to Maltese and Tai (2010), in the research conducted with various professional and academic scientists, they found that participants had a science interest from an early age. Additionally, some research has noted that certain students lose their interest in science during late middle school or early secondary school. As a result, when students start losing interest, they may distance themselves from science and plan their careers in other fields (Steidtmann *et al.*, 2023; Potvin and Hasni, 2014; Riegle-Crumb *et al.*, 2011; Clark Blickenstaff, 2005).

A useful example of this comes from research conducted by Maltese and Tai (2010) who reported that an interest which comes from a strong individual motivation for STEM related subjects is more crucial for students who would like to have a career in those fields than for students who do not. As Renninger (2000) stated, when there is interest, people tend to spend time on that content, think about it, and make plans related to it. Additionally, individuals with interest in certain content or subjects tend to question with curiosity – a quality particularly important in scientific fields. Moreover, interest could be a source of motivation, and both –interest and motivation – lead individuals to study science, pursue a career in science, and develop science identity.

Beliefs that individuals hold about themselves, particularly about their skills and capabilities, can impact their actions, such as questioning, participating in learning environments (Pajares, 2002; Vincent-Ruz and Schunn, 2017). Cambridge Dictionary defines competence as "the ability to do something well". However, the conceptualisation of competence in science could vary within difference studies. For example, related to science identity and its conceptualisation, Carlone and Johnson (2007) designed a model for science identity – research that is widely referred to by scholars because of its significant influence on and contribution to existing science identity literature. To represent the essentials of science identity, their model was composed of three components: competence, performance, and recognition. Each represents related qualities such as being able to use tools or participating in scientific speech/discussion (performance), learning science content and getting acknowledged (competence), and identification and recognition with science (recognition). Furthermore, in my research, competence in science refers to both competence and competency beliefs. This means that individuals are able to perform well in science and believe in their science performance in areas such as questioning, participating in science lessons, performing well in hands-on activities and experiments.

Moreover, few studies have addressed career aspirations in science and conceptualisation of science identity (Hazari *et al.*, 2013). Moreover, science career aspiration of students may be related to having a significant level of science interest and being willing to be in the fields of science. Therefore, the conceptualisation of science identity in this research was based on factors such as identification and recognition as a science person, interest in science, competence in science, as well as the science career plans of students.

The reason for choosing multiple components was that there may not be one parameter, or it may not be possible to decide or understand whether a participant has a science identity. For example, sole identification as a science person could be the parameter; however, it would not be sufficient to confirm that it reflects a student's true feelings about or identification with science. However, there is also concern about current and future career orientations in terms of science identity, especially for younger learners who are still a few years away from deciding the pathways they will take and their subsequent adoption of professional roles. Thus, a science identity might exist without a commitment to a particular career. Put differently, thinking about having a science-related job in the future may be a sign of possessing a science identity because this may represent an intention to work in the field of science. Therefore, in this case, concentrating on how individuals construct their different identities and conceptualise the important values in their lives during secondary school years, especially Year 10 students, who are the focus of this research, just before choosing the main education pathways through which to invest their effort into a potential career could elucidate how science identity can be influenced by the intersection between gender, religion, and ethnicity. However, the instability (or changeability) of identity construction should not be overlooked. This has also influenced scholars' perspectives on science identity and how it is conceptualised. For example, Hazari *et al.* (2013) conceptualised science identity as the identification of one's own self as a science person; thus, science identity is defined as a person's own perception of who they are and includes science as part of that identification.

The broad coverage and detailed characteristics related to science-related experiences within Carlone and Johnson's (2007) work were useful in guiding my research in terms of identifying valuable characteristics of science identity whilst conceptualising and studying it. Furthermore, those studies conducted to explore science identity within various contexts and with different focuses assisted me in conceptualising my research components because there were similarities and differences to take into account to improve my research and obtain a broader understanding of what has been done in the literature. For instance, the recognition of individuals regrettably remains significant, and is an essential component of the conceptualisation of science identity; additionally, traditional concepts or stereotypes were also factors I would potentially be faced with in this research. This may also be related to a feeling of belonging to science fields, the competence of individuals in science, and to some extent the importance of support for those who develop a science identity. However, in my research it was important to adopt a comprehensive and consistent framework in terms of science identity. Therefore, both intrinsic attitudes such as interest and confidence and external factors such as recognition and career aspiration were taken into account, and this was how science identity was conceptualised.

On the other hand, there are various factors that may influence science identity, such as family, parents' educational backgrounds, and socioeconomic status. For example, DeWitt *et al.* (2016a, p. 2437) conducted a study on science capital which they essentially conceptualised as 'science-related forms of cultural and social capital'; thus, science- related cultural and social capital include factors such as family science resources or participation in science activities (Archer *et al.*, 2015). They asked their participants several questions which captured intentions towards future participation in science. Regarding science capital, in an earlier project the ASPIRES study explored the science and career aspirations of students (aged 10-14). In this research, Archer *et al.* (2015) found that if students' families had a greater number of science-related resources, students were more likely to display science and career aspirations in science-related fields. Archer *et al.* (2015) then conducted research to analyse science capital and different kinds of cultural capital to understand and ascertain how to measure science capital via surveys. The results revealed that science capital is related to families who have science-related resources that build and preserve their children's science interests and aspirations. Methods of support could be providing information within daily life, being able to afford science kits, watching science TV, and joint in science activities together. Whilst science capital can be useful in terms of understanding how cultural and social sources affect science engagement or science identity development, it was not the primary focus of this research. The absence of science capital does not undermine its importance, nor that of social and cultural capital, but by narrowing the focus, the main aim of the research was to understand how gender, religion, and ethnicity and their intersections influence the science identity of students.

Additionally, the methods for assessing science identity also vary. For example, a method can be adopted to assess science identity indirectly through the actions a learner takes (Archer *et al.*, 2010; Barton *et al.*, 2013) or directly by asking learners about their identity via surveys (Barton *et al.*, 2013). In my research, I decided it would be useful to conduct mixed-methods data collection to explore and understand how students' science identity was influenced by their gender, religion, and ethnicity. The research methodologies are detailed in the following chapter which focuses on methods and methodology. Although neither science capital nor any other kind of capital were taken into account as factors that may affect the science identity of individuals, this does not mean that such capitals do not have an influence; they were just not the focus of this research. If science capital or any other capital had been included, socio-economic factors such as the socio-economic status of families and social and educational backgrounds would also need to have been considered. This could have made the research more complicated; therefore, detailed investigation would not have been achieved as planned.

Furthermore, some studies addressed various factors that impact science identity which were different from the factors studied in my research; nevertheless, the perspectives of scholars and the ways in which they conduct their research were beneficial for improving the potential understanding related to my research topic. Therefore, these studies shed light on my research to explore how the focal elements of gender, religion and ethnicity influence science identity through the lens of intersectionality. Although these studies focus on elements that may be potentially influential, they do not consider the intersecting influences between these factors. In addition, the mixed-methods design of the research and the research context and schools in London were helpful in investigating several specific, but nuanced points, such as the impact of ethnic diversity among students on their science identities. Regarding intersectionality, further details on this are presented later in this chapter.

The reason for focusing on gender, religion and ethnicity in this study is that various factors have been studied and several significant influences in science identity have been explored; therefore, these three elements and their intersectional impacts on science identity could be significant and merit further investigation in determining how they influence science identity development. Also, as mentioned previously, I chose gender, religion and ethnicity as the focal elements of the research based on my personal experiences and what I observe in various social groups. Conversely, the reason for not including characteristics such as sex, sexuality, class, parents, place of birth and upbringing, language, preference for studying particular subjects, race, culture and subcultures in order to generate a deeper understanding is that feasibility is desirable and essential in research; hence, I needed to minimise the number of components that may impact science identity, as well as limiting the number of participants.

Following the discussion on the topics of identity and science identity, another important point to address is the relationship between different identities, as some identities might be stronger than others, and hence may have more effects than others. It is not easy to determine why one identity is more powerful than another, but interplays between identities affect identity holders in various ways. Occasionally, studying human participants can be challenging because of their tendency towards uncertainty; for example, in obtaining a clear understanding, certain answers or explanations, or achieving predictable outcomes. For instance, two people could have similar backgrounds, characteristics, and the same origins, but their identities could turn out to be different; this could be because of what they like to do, what they hate, or something they have never experienced. The importance of identities and the numerous perspectives and methods adopted to find out various points related to identity and identity development have been examined by scholars. Turner (1978) studied and conceptualised voluntary and obligatory identities according to role identity. Obligatory identity refers to a more important and powerful identity of an individual; hence, it is difficult to ignore in different contexts and over time as a fundamental identity. To provide clarification and avoid any misunderstanding, further explanation and discussion about obligatory and voluntary identities with reference to recent studies are provided in the following section.

2.1.3 Voluntary and Obligatory Identity in the Context of Role Identity

Because the meaning of identities is partly based on individuals' perceptions of how others view and evaluate them, Gallagher (2016, p. 309) stated that "individuals have an identity for every role they occupy, and that each identity contains a set of meanings that may or may not overlap with that of their other identities". Turner (1978) claimed that role identities could be divided into two categories, obligatory identity and voluntary identity. Gallagher (2016) also categorised roles into voluntary and obligatory identities. From the point of view of classical role identity theory, Turner (1978, p. 1) differentiates between roles that "are put on and taken off like clothing without lasting personal effect" and those that "are difficult to put aside".

In terms of my research, existing studies include different types of identities when compared to my research topic regarding obligatory and voluntary identities; for example, my research focus was on science identity, but Turner (1978) and Gallagher (2016) mostly focus on partner, parent, or work identities whilst working with role identities. Thus, it is worth exploring role identities and their association with science identity; the concept of voluntary and obligatory identities could be useful in understanding how and/or why students' science identities differ depending on the time and place when they need to activate an identity. Obligatory and voluntary identity development does not mean that a person is obligated to develop a certain identity; it is mostly related to how much that identity is valued in the life of the person. For instance, I would like to state my assumption related to role identity in terms of obligatory and voluntary identities: a student who has both religion and science identities, where the student's science identity is voluntary, places more value to his/her religion. Therefore, the religious identity has become an obligatory identity for him/herself. When the student faces any conflict between his/her religion and science identities, a voluntary science identity can easily be put aside, whereas the student cannot easily ignore his/her religion because of the obligatory religious identity. On the other hand, there are numerous possibilities for developing different, and possibly more than one, obligatory and voluntary identity. There is a need to understand how constructed identities intersect and influence each other. This perspective gave me a chance to fill a gap in the literature and examine science identity from a different perspective.

The conceptualisation of science identity and how it is constructed over time and across contexts is considerably diverse. Hence, in my research, I conceptualised the nature of science identity as fluid, tentative, and dynamic. As stated previously, individuals have multiple identities, and these interact within both individual and social structures. Taking into consideration the relationships among multiple identities, intersectionality can potentially highlight the inseparability of social structures and characteristics such as ethnicity, gender, social class, and religion (Avraamidou, 2019b).

2.2 Intersectionality

2.2.1 What is Intersectionality in this research?

Crenshaw (1989) used the term ‘intersectionality’ to describe how the race and gender identities of women of colour experience oppression through overlapping and intersecting. Crenshaw centred on black women to show that the single-axis framework of discrimination analysis, focused on either race or gender, overlooks people who have multiple intersecting identities and ignores those who are harmed by a combination of inequities (West, 2019). Intersectionality cannot be stabilised at any personal and institutional level of analysis because of its dynamism, depends on context and understanding. For example, according to Ferree (2011), a dynamic view of intersectionality emphasises that intersecting gender and race is not associated with one specific group, for example black women; however, it is a process in which the interaction of race and gender could be various for different people. In other words, race could be interpreted or experienced in various ways according to gender (women, men, or who are not identified in these groups) and what is seen and by whom. These various interpretations are the result of individuals, contexts, locations, and environments.

Collins and Bilge (2020) examined multiple aspects of intersectionality, but the main focus of their book was to present intersectionality as an analytical tool. This is in line with Cho *et al.*’s (2013, p. 795) argument that "what makes an analysis intersectional is not its use of the term ‘intersectionality’, nor its being situated in a familiar context, nor its drawing on lists of standard citations”; their focus is on “what intersectionality does rather than what intersectionality is". From this point of view, the importance of intersectionality is that intersectionality allows me to take gender, religion, and ethnicity as influential components into account whilst studying science identity with the belief that each individual interprets these components differently and exhibits varying behaviours as a result. With full respect for the importance of intersectionality and its diverse applications, I would say that the use of the terms of 'intersectional lens' and 'lens of intersectionality' refers to ways of viewing and understanding phenomena within this research context, which is grounded in intersectionality.

According to Dill *et al.* (2007) and Núñez *et al.* (2020), intersectionality is grounded in feminist theory, which asserts that people possess multiple, layered identities and can simultaneously experience oppression and privilege. It is an approach to creating knowledge that has its roots in the analyses of the lived experiences of women of colour – women whose scholarly and social justice work reveal how aspects of identity and social relations are shaped by the simultaneous operation of multiple systems of power. Therefore, in my research, intersectionality was helpful in identifying the overlapping effects of different identities such as religious, gender, and ethnic identities on science identity. The main reason for incorporating intersectionality was to understand how students' science identity may be influenced by their various identities and values. That said, it is important to recognise that the collective impact of these identities may vary significantly. This study aimed to investigate and gain insight into this complex situation. Thus, the importance of intersectionality in the research lies in what intersectionality does, rather than what intersectionality is. I believe it is important to mention the roots of intersectionality in feminism to be able to benefit from it.

Feminist thought originated within the social movements for change (White *et al.*, 2019), and this is useful in understanding its variations. "A feminist is a person who favours political, economic, and social equality of all people, regardless of gender, and therefore favours the legal and social changes necessary to achieve gender equality" (Else-Quest and Hyde, 2018, p. 6). Just as societal needs have changed over time, so too has feminism. For instance, several different but related areas have been the focus of feminism's attention. In the late 1800s and early 1900s, feminists concentrated on equal rights; during the late twentieth century, their attention then turned to various fields such as female psychology, the culture of femininity, and the basis for female nurturance and mothering (White *et al.*, 2019). Historically, there have been obvious periods of feminism that are referred to as ‘waves’.

Feminist activism has been uneven in social science disciplines and across different geographical locations. Because of this situation, Kandiyoti (1995, p. 2) states that "it is therefore unrealistic to attempt a comprehensive account of the field beyond a necessarily schematic and selective presentation". With this disadvantage in mind, scholars have proposed periodisation, which refers to different moments within feminist theorising rather than considering events in chronological order. These periods of time are referred to as the first-, second-, and third waves of feminism (Heywood and Drake, 1997; Kandiyoti, 1995). However, the important point here is that in current publications, a fourth wave of feminism has been introduced. The following table briefly presents the characteristics of the waves of feminism, and their corresponding periods.

Table 1 Waves of Feminism

Feminist wave	Corresponding period	Characteristics of the wave
First-wave	Late 1800s and early 1900s	These feminists fought for women’s right to vote, and they succeeded. In the United States, women’s right to vote was won when the Nineteenth Amendment to the U.S. Constitution was ratified in 1920. This phase provided the initial challenge to mainstream social science and produced a rich harvest of studies making women visible as historical, social, economic, and political actors.

Second-wave	Began in the 1960s and extended into the 1990s	Second-wave feminists could build on the successes of their predecessors and take on a much wider range of issues: sexual freedom; reproductive rights, especially contraception and abortion; pay equity; equal opportunity in education; and gender-based violence.
Third-wave	Began to emerge sometime in the 1990s	Third-wave feminism represents a rebellion against second-wave foremothers and attempts to rectify some of the perceived weaknesses of the second wave. One of the key criticisms of second-wave feminism is that it tended to essentialise and oversimplify the category of ‘women’ by focusing on ‘universal’ female experiences such as motherhood. In so doing, it ignored the immense diversity among women along lines of race and social class. Third-wave feminism emphasised intersectionality – an approach originating in black feminism – and diversity among women rather than the universality of the female experience. In addition, it favours the individual’s right to define feminism, instead of everyone accepting a uniform ideology.

Fourth-wave	Began in the early 2000s	We are currently in the period of the fourth wave of feminism, which has been fuelled by recent advances in online technology, including user-generated content such as blogs and social media such as Twitter, Facebook, and Instagram. Building on the third wave, it also includes a greater emphasis on intersectionality and the critique and rejection of the gender binary. Thus, transgender issues are more prominent than in previous waves.

(Kandiyoti, 1995; Nally and Smith, 2015; White *et al.*, 2019, Else-Quest and Hyde, 2018)

While feminism has focused on various areas and issues by highlighting equality and equity, it is essential to apply its principles to science and gender-based issues, with a particular emphasis on science education. Regarding gender and science education, Brotman and Moore (2008) conducted a systematic and comprehensive review of the literature and developed four themes. They also highlighted how these four themes are related or parallel to the three waves of feminism. This explains why feminism and science or science education are important in this case. There has been a vast amount of attention on gender studies within the science context, science fields, and science education. In essence, it is about women in science. As a main element of the research, education, especially science education, is important. The reason for the three waves of feminism mentioned by Brotman and Moore (2008) is that the authors were drawing on the feminist perspective of Calabrese Barton (1998); as stated above, the fourth wave of feminism began in the early 2000s. The following table briefly summarises the four themes and the waves of feminism.

Table 2 Four themes of gender and science education in Brotman and Moore's (2008) research and how the four themes run parallel to three waves of feminism

Four Themes of Gender and Science Education	Waves of Feminism

Theme 1: "A focus on equity and access": This theme discusses gender gaps and injustices in the classroom, highlighting the importance of providing girls with equitable science opportunities if there is need to encourage them to pursue careers in science.	The first wave of feminism, for example, refers to the 1960s women's movement and overlaps with studies in Theme 1 that advocate for equal access to science. In terms of science, the first wave of feminism aimed to ensure that males and females had equal access to the study and practise of science. Furthermore, the wave advocates the need to change inequitable societal structures. This underpins many of the research studies in Theme 2, which focus on modifying curriculum and pedagogy, and Theme 3, which focuses on changing the nature and culture of science.
Theme 2: "A focus on curriculum and pedagogy" This theme stresses the need to adapt scientific classroom curriculum and pedagogy to integrate females' experiences, learning styles, and interests.	For example, second wave feminist analyses seek to recognise and incorporate many "ways of knowing" into science (Barton, 1998, p. 8). Many studies in Theme 2 focus on second wave feminism in order to make girls' learning, interests, and experiences important in the science curriculum and pedagogy.
Theme 3: "A focus on reconstructing the nature and culture of science" This theme focuses on the need to reimagine how science is displayed, interpreted, and characterised in schools and society.	Studies in Theme 3 and Theme 4, which focus on gender and

Theme 4: "A focus on identity" This theme underlines the importance of assisting females in combining science into their many identities as individuals.	identity conceptualisation more broadly, are appropriate for third wave feminist ideas that place more emphasis on intersections between race, class, and gender and adopt a more political, activist stance towards changing science education.

(Calabrese Barton, 1998; Brotman and Moore, 2008, p.976)

As stated above, intersectionality has been associated with feminism, most notably with the third wave (White *et al.*, 2019). Thus, it serves as the hallmark of third-wave feminism while also broadening the theoretical approach of feminism (Allen *et al.*, 2013). Therefore, whilst benefiting from intersectionality, it is necessary to emphasise how I integrated intersectionality into my research. The first vital point to highlight is that intersectionality has been developing as an academic discipline (Núñez *et al.*, 2020), hence, there is no single way of using intersectionality, which makes it beneficial as it can serve as a lens, a framework, or an analytical strategy. In addition, Collins (2023, p.152) identified two important areas of intersectionality: 'analytical strategy' and 'as a form of critical praxis'; the former refers to understanding how different identities overlap and influence experiences and opportunities in diverse social environments; and this was the main rationale for adopting intersectionality in this research. Therefore, an intersectional lens was utilised in order to understand individuals' experiences whilst developing identities; in particular, to address two or more identities that influenced their experiences. The latter means intersectionality plays an important critical framework role, which refers to the application of theoretical frameworks derived from academia to real-world situations. The form of the critical praxis role of intersectionality and transformative paradigm relations within this context are explored later in this section.

My goal in this particular part of my thesis is to elucidate the complexity of gender, religion and ethnicity; that is, when, why, and how these matter in the development of students' science identity. Firstly, there may be many more questions to ask about gender and how it influences individuals. There are multiple terms related to gender, such as sex, gender binary, gender identity, cisgender, transgender, intersex, and so on. Some of these terms will be explained in the gender and gender identity section of this work if any of these are used in the research.

The view of the feminist movement, especially the concept of intersectionality, attributes importance to an understanding of the connectedness of personal experiences, the context of communities, and cultures; this is crucial not only for our knowledge but also to improve the conditions in which we all live. The influences of individuals' lives on a wider context refers to a concept called "'the personal is political', which means that social roles, norms, policies, and laws have significant impacts on the elements to consider in people's lives" (Else-Quest and Hyde, 2018, p.42). Furthermore, the concept of 'the personal is political' may serve as the transformative foundation of intersectionality.

The starting point of the transformative roots of intersectionality has been the work of feminism and feminists of colour, who have theorised the interrelationship between race, class, gender, and other dimensions of differences. However, for the transformative paradigm identified by Creswell and Plano-Clark (2011), any research that adopts this paradigm aims to improve the circumstances of its participants, which means that the researcher works collaboratively with them to improve the life situation of disempowered groups and individuals. Moreover, this approach focuses on issues relating to the agentic control of one's life; namely, power, empowerment, social justice, marginalisation, and oppression. The transformative paradigm also emphasises the need for having a voice and taking action within a society. However, an important nuance regarding the transformative approach is highlighted by Cohen *et al.* (2018), in that the aim can be answered with this question: "Does the research have an explicitly political agenda?" In my research, there were parts/outcomes that might be considered political stances, but the research did not directly turn to a political agenda by adopting the transformative paradigm.

The previous section explained intersectionality, its use as a lens, and its connection to feminist theory. Benefiting from the lens of intersectionality, gender, religion, and ethnicity impacts on science identity were studied in this research. Therefore, the next section will delve deeper into conceptualising gender, religion, and ethnicity.

2.3 How Gender, Religious, and Ethnic Identities Were Conceptualised in This Research

Hammack (2014) highlights the complexity of the world people inhabit regarding identification, naming, and/or categorisation regarding the connection between who and what individuals are, and to what sort of larger categories they belong. These categorisations could be gender, class, race, ethnicity, nationality, sexual identity, occupation, and so on. Therefore, understanding students' different identities and experiences could allow us to recognise and problematise existing discourses that psychologically and/or physically influence their science identity development.

2.3.1 Gender Identity

Sex and gender, as terms, are sometimes used interchangeably in education (McGeown and Warhurst, 2020). However, despite some common points, the two terms are totally different. Different disciplines and scholars adopt various perspectives and approaches regarding the relationship between sex and gender, and these are influenced and shaped by various elements, such as values, norms, and other sociocultural factors. For example, sexism and gender bias are some of the mechanisms which are at the intersection of sex, gender, and social values. Therefore, to clarify, sex reflects the biological differences between boys and girls, whilst gender is socially constructed and reflects characteristics associated with being male or female. '"Sex' is constituted by a perceived or actual convergence of hormonal, chromosomal, and anatomical factors that lead to a person's classification, usually at birth, as 'male', 'female', or 'intersex'" (Pfeffer, 2010, p. 166). Regarding the latter, intersex individuals have sex chromosomes, external genitalia, and/or the internal reproductive systems that do not fit the standard for males or females. Thus, the term 'sex' refers to individuals' genetic and anatomical characteristics, which include the genetic and chromosomal combination of the individual (XY in man, XX in woman), internal and external reproductive organs (penis in man, vagina in woman), and secondary sexual characteristics (which appear during puberty; for example, facial hair on males and breasts on females) (Vargel-Pehlivan, 2017).

By contrast, gender is socially constructed based on an individual's sex and reflects characteristics associated with being male or female; indeed, both boys and girls vary in the extent to which they identify with stereotypical masculine and feminine traits (i.e.

their gender identity) (McGeown and Warhurst, 2020). Therefore, gender characteristics are interpreted within a sociocultural context and societal expectations of both women and men are shaped and changed in relation to their values. However, such expectations differ across societies (Gürhan, 2010). Children's gender identity thus develops from socialisation experiences, where receiving feedback for gender-appropriate behaviour, modelling others (e.g. parents, peers), and direct instruction on gender roles all contribute to the formation of gender identity (Bussey and Bandura, 1999).

Hull (2006) discussed the ontology of gender as involving an examination of the fundamental nature and existence of the gender concept as well as sex. Social constructivist and poststructuralist perspectives critically examine the nature of sex categories and challenge the notion of fixed gender distinctions. However, the exploration of the ontology related to sex and gender, according to Hull (2006), does not cover various gender identities and the relationship between gender and culture, despite its involvement in the critical analysis of various genders. In terms of gender and gender-culture relations, gender identity development may be influenced by recognition from people in social environments or groups who hold cultural values, and recognition is an important component of identity according to Gee's (2000) identity conceptualisation.

In terms of gender and its relation to social values, gender identity development may be influenced by recognition, which is an important component of identity development as conceptualised by Gee (2000). Communities that individuals belong to hold social values that may influence identity development in various ways through recognition. These influences can be varied — including race, morphology, sex, ethnicity, and categorical understanding — all of which may lead to different treatment and recognition. Moreover, the interconnected perspective addresses the nuanced interplay between recognition, the need for recognition, social norms, and the complex understanding of individuals' multiple identities.

In shaping my own theoretical stance related to gender and sex, I found it important to critically engage with a range of perspectives, including feminist, poststructuralist, and social constructionist approaches, all of which challenge the essentialist and biomedical understandings of sex and gender (Hull, 2006; Pfeffer, 2010; Else-Quest

& Hyde, 2018). Through this process, I came to appreciate the contributions of third- and fourth-wave feminist thinking (White et al., 2019; Kandiyoti, 1995), particularly their emphasis on gender as fluid, socially constructed, and deeply influenced by broader systems of power. In this research, I adopt a social constructionist position within an interpretivist paradigm, distancing myself from deterministic views of identity. My position is that neither sex nor gender is fixed or purely biological. This position directly informs how I have approached the concepts of sex and gender in this research: they are socially constructed, context-dependent, and shaped by participants' preferences and lived experiences.

From a social constructionist perspective, even these classifications are interpreted through sociocultural lenses, meaning they are not entirely objective or value-neutral. By adopting this view of sex and gender as constructed and situated, my aim is to explore how students' science identities are influenced by their gender, religion and ethnicity — recognising that participants' gender itself may also be influenced by ethnicity and religion — without assuming these categories have fixed or universal meanings. For example, asking participants about their sex in the survey does not necessarily refer to their sex assigned at birth, but to how they identify themselves. My theoretical standpoint aligns most closely with the understandings and critiques of the most recent wave of feminism, as well as Gee's (2000) identity framework, which sees identities as multiple, dynamic, and shaped by various influencing factors.

The family is recognised as the most influential context in which the child develops; it shapes gender, gender roles, and behaviours from the beginning of life (Kakavoulis, 2001). From birth, individuals are social creatures who take an active part in family and society throughout their lives. As individuals grow up, their families may encourage them to learn and exhibit behaviours considered masculine and feminine in accordance with their sex and culture. As children learn their expected gender roles by imitating and/or observing their parents, their families sometimes give them explicit and implicit messages (Kimmel and Messner, 2007; Harris and Harper, 2008). However, gender roles in society are mutable, shaped by cultural and social views (Tekke *et al.*, 2019), and may also affect individuals' thinking and behaviour (Mills *et al.*, 2012).

Even though the focus is on how gender influences students' science identity, it's important to recognise that gender, as a socially constructed identity, exists within wider systems of power and inequality. Terms like sexism, misogyny, and patriarchy are not just theoretical — they are part of lived experiences that can shape how gender develops and is expressed. According to definition of Else-Quest and Hyde (2018, p. 5), "sexism or gender bias can be defined as discrimination or bias against people based on their gender". Sexism does not occur in any particular group, such as men, or people with certain backgrounds and values; regardless of their gender and the social groups to which they belong, anyone can engage in sexist behaviour or hold sexist attitudes. Therefore, misogyny and patriarchy could be sources and/or outcomes of sexism. According to Wrisley (2023, p.192), misogyny, etymologically rooted in 'hatred' and 'women', is a negative emotional orientation towards women. Sexism is rooted in sex and '-ism' and refers to the ''process or action of 'systematic prejudice or discrimination'. Misogyny and sexism impacting together produce a persistent system of dominance over women, although it is important to make a distinction among various contexts where misogyny and sexism work together and reproduce each other (Wrisley, 2023). For example, women may suffer greatly from patriarchal attitudes and institutionalised sexism, which act as a barrier in their everyday lives in areas ranging from family duties to their roles in the workplace (Aycan, 2004).

However, the patriarchal order has both oppressive (requiring women's obedience and dependency) and protective (responsibility of men to protect the family) sides. Women have a degree of power (for example, a woman becomes more powerful if she has son(s) or does not have to work to finance herself) and autonomy within this system (Yavuz, 2015). Therefore, although women may seem oppressed within this patriarchal system, they may also comply with it. Kandiyoti (1997) calls this 'patriarchal bargaining'. According to Millett (1977, p. 36), the nature of patriarchy is twofold: 'men dominate females and elder people dominate the young' - a feature that leads to its own perpetuation (Yavuz, 2015). Yavuz (2015) explains that as responsible parents nurture children and encourage them to develop gender roles, some mothers also adopt patriarchal attitudes. Having grown up in this system, they may have learned that power comes with having sons or getting older. Therefore, to some extent, they intrinsically support patriarchy by promoting gender roles, and this is how patriarchy continues to exist across generations.

The changeability of gender roles can be seen during adolescence because adolescents are highly likely to conform to gender roles (van der Vleuten *et al.*, 2016). From the perspective of gender socialisation theories (Fagot *et al.*, 2000), adolescents tend to internalise their gender role expectations, which come from their gender ideology, and they conform to the behavioural prescriptions of their gender category because doing so confirms their identity (Sinclair and Carlsson, 2013). Conversely, adolescents may try to escape the confusion and guilt that come from not living up to their own ideas about gender roles. Therefore, any overrepresentation of men or women in educational fields can influence students' perceptions of what is considered typical 'feminine' and 'masculine' behaviour or 'for girls' and 'for boys'; this may reinforce traditional gender roles and increase gender inequality (Geerdink *et al.*, 2011). Therefore, developing a science identity or attitudes towards science is important during adolescence, especially when identity conflicts occur. Adolescents may develop stereotypes or lose their interest because of a lack of information or the misrepresentation of science or science fields.

In terms of gender and science attitude trends, these topics have been studied by some scholars such as Barmby *et al.* (2008), Christidou (2011), and Aznam (2022). Additionally, adolescent girls often face gender stereotypes related to their self-concepts and perceptions of science that may limit their science career plans. Further, the male-dominated science stereotype may negatively impact girls' attitudes towards science (Barmby *et al.*, 2008; Christidou, 2011). Attitudes may influence one's positionality related to science; for example, individuals' interests, confidence, and career plans may be shaped by their attitudes towards science (Wang *et al.,* 2023). An attitude refers to emotions expressed towards specific things, which can be unfavourable or favourable, or positive and negative (Sofiani *et al.*, 2017). Ultimately, attitudes might depend on various factors and values. Therefore, research results, in regard to gender and science, might differ according to the place where the studies were conducted, the ages of the participants, the characteristics of their families, the communities to which they belong, and the environment in which they are situated. For example, in the study by Aznam (2022) involving primary and secondary school students in Indonesia, female students showed more positive attitudes towards science compared to male students. Therefore, for my study, I explain the educational context and the environment in which the participants mostly live, together with their demographic information, to establish the specificity of this research to this content or similar types of content.

Other research based on gender differences has found that females avoid vocational choices such as being engineers or technicians even if they have the same ability in science as their male peers (Shirazi, 2017). Related to gender, Jackson *et al.* (2019, p. 149) stated that “women and men may experience different social environments within the STEM fields, it is expected that certain social mechanisms, like social recognition, would also impact them differently”. For instance, Lock *et al.* (2013) found that compared with women, men are more socially recognised as a person in maths and/or in physics. Men’s social recognition in science aligns with the historical stereotype of male dominance in science. In the research conducted by Eren (2021), women in science and how males are offended by women’s presence in science was criticised. The Royal Society, the oldest autonomous scientific institution, which was established in 1660, denied Marie Curie admission to the Académie des Sciences for her second Nobel Prize. Another example related to the gender and science relation could be a Nobel Prize scientist’s comments on female scientists causing trouble for men in labs (BBC, 2015).

Occasionally, gender may not be the only factor influencing people in science fields; for example, Carlone and Johnson (2007) studied science identity with women of colour who were asked about their thoughts and experiences related to pursuing a career in science fields. Some reported that gender, race, or ethnicity came to the forefront, despite their science abilities. Therefore, their science identity development and position in the field of science were disrupted. Indeed, intersections between gender, race, attitudes towards science, and awareness of abilities and qualifications could be significant factors determining whether females choose to have a job in science-related fields and/or develop a science identity. However, science may not be for everyone, especially if individuals have interests in different subjects or fields such as literature, art, or music and lack the necessary abilities and interest to engage with science.

Although my research focused on the impacts of gender, religion, and ethnicity on science identity through the intersectional lens, this does not imply that these factors inherently make developing a science identity difficult or necessarily enhance its development. For example, as mentioned previously, the experiences of women in science-related fields may be considered just an outcome, but it is worth exploring the impacts and processes experienced by individuals who potentially may have a science identity. Therefore, if there are any impacts coming from these factors and some individuals have the tendency to adopt a science identity whilst being influenced by them, the principal aim is to investigate how these people experience and handle the influences to develop their science identity.

2.3.2 Religious Identity

To be able to talk about religious identity, the relationship between science and religion, the concept of religion in this research shall be discussed within the focus of these questions: What is religion and how is it conceptualised in this research? As highlighted by Catto *et al.* (2023, p.97), the importance of referring to more inclusive terminology which is "'science and religion' rather than 'science and Western Christianity'" is important, therefore, in line with this approach, a broad term for religion is used in this study. Religion in this research is conceptualised as spiritual or religious beliefs, which means any divine related beliefs. In addition to this, the holy faith of individuals and the lack of divine commitment are other forms of belief preferences that were considered in this research. In Nishitani's (1982) discussion of the nature of religion, two important remarks were highlighted; first, religion is always a personal matter, and second, the essence of religion is not understandable from outside; thus, religious inquiry is the only way to comprehend it, and no alternative method exists.

Moore and Scott (2007) simply explained the relationship between the essence of religion and religious realism/antirealism. This relationship is based on individuals' understanding of religion; in other words, these understandings shape people's position on whether religious truths exist objectively or are subjective creations. Realism-based religious perspectives claim that religious views correspond to an objective reality. By contrast, antirealist religious perspectives assert that religious claims are primarily expressions of personal beliefs; also, in a religious context, it is difficult to understand the nature of truths that are established through internal criteria within religious discourse (Moore and Scott, 2007). The discussion, mostly positioned in the field of philosophy of religion, centres on topics such as God’s existence and the logical consistency of religious claims. However, the essential and common point to focus on is that although, as a belief system, religion is a personal matter, the interpretation of this and the resulting actions can have social implications and influences.

In this research context, the relationship between religion and science can be seen from two different perspectives. The first covers the effects of religious beliefs on science learning, or how religious beliefs may affect attitudes towards science. For example, a negative disposition towards topics related to evolution among some believers of Abrahamic faiths such as Judaism, Christianity, and Islam (Scott, 2009). Or another instance could be that there are people who believe in various interpretations about prohibitions regarding blood transfusions or organ transplantation. However, as highlighted by Bruzzone (2008) and Messina (2015) no religion forbids organ transplantation. When a believer needs blood transfusions or organ transplantation, this could result in a life-risking decision or one that is not appropriate for the religion.

The second perspective is related to the impacts of religious identity on one’s science identity. In other words, the relationship between religion and science can change the personal preferences and individuals’ identity development. This may be a broad concept and could cover the first one; however, the nuanced point to highlight here is that the first one can be more personal whilst the second is both personal and social. For example, a person who has a strong science identity and dreams of becoming a surgeon may also believe that blood transfusions or organ transplantation are forbidden in their religion. In such a situation, the person may either choose to pursue his or her dream and go against the religious beliefs or abandon his or her aspiration and choose another profession that aligns with his or her beliefs. This decision depends on the strength of his or her desire to become a surgeon, and how religious the person is. From the example given above, the religious beliefs of individuals could influence science identity by creating conflicts; correspondingly, according to English and Bolton (2015), science education could become more accessible to all students by challenging norms, understanding who students are, and exploring how their identities can operate together in relation to science.

The religiosity of individuals may be considered a component of their identity, similar to their norm-based attitudes. Moreover, individual religiosity is important to take into consideration because it may not be visible or easily understandable. As highlighted by Van Klingeren and Spierings (2020), individual religiosity could vary in terms of the extent to which a person is religious; furthermore, there is a possibility of people acting differently in private according to their level of religiosity. The cultural or environmental patterns that surround individuals have been found to influence their socialising and identities (Glenn, 2003; Van Klingeren and Spierings, 2020).

Neither religious beliefs nor other norm-based attitudes are constant; therefore, the possibility exists to change the religiosity of individuals throughout their life, and acts that are norm-based could differ by time and place. For example, regarding how religion may influence ways of living, Stevens (2007) claims that specific religious obligations, especially those related to Islam, act as restrictions for girls wanting to achieve the highest in education. In another study, Abbas (2002, 2003) explored how ethnicity, religiosity, social class, and gender relate to the educational opportunities and experiences of South Asian pupils. Abbas (2002, 2003) reported that, although South Asian parents appear to value educational achievement, South Asian Muslim (Pakistani and Bangladeshi) girls perceive specific religious and traditional values as being a barrier to educational and occupational success.

The importance and influence of religion in science education are significant because, as stated by Gondwe and Longnecker (2015), religion can also be an implicit component of culture as a belief system that can shape people’s world view. Similarly, Jochman *et al.* (2018) highlighted the value of trusting, positing that understanding science could be influenced by religious beliefs or other belief systems through pre-existing attitudes or inclinations. Additionally, broad societal differences in the opinions of members of religious groups could be generated by pre-existing attitudes or inclinations; hence, the value predispositions related to religion function in complex ways for each individual. The information shortcuts created by value predispositions may exert powerful effects on processing, criticising and using new scientific information.

A widely known example could be the discussion about creationism and evolution. Such perspectives vary in their conception of the beginning of the world. For example, people may believe in certain religions and support creationism. Conversely, believers of a religion originally based on creationism may agree with the explanation of evolutionism which is independent of any religion. The important point to stress is the need to be open to learn, judge and use information where there is a conflict, but regrettably value predispositions can sometimes affect this process.

Moreover, the conflict between science and religion could be the result of various factors such as 'source of knowledge' (Evans and Evans, 2008, p. 89) or belief or disbelief (Asiyah *et al.*, 2023). Creationism, evolution theory, their conflicts and learning about and teaching them within science education are popular topics that have been widely discussed by scholars (Leicht *et al*., 2022; Scott, 2009; Reiss, 2008; Reiss, 2014; Allgaier, 2010). In a broad sense, the universe, earth and all living organisms are perceived as being created by God for Christians, Jews, and Muslims, or by other deities for believers of other religions or faiths (Scott, 2009; Reiss, 2008). Regarding evolution, Scott (2009, p. 23) defines it as "the cumulative, or additive, changes that take place in phenomena like galaxies, planets, or species of animals and plants. It refers to changes that take place in groups rather than in individuals and to changes that accumulate over time".

Another approach to the origin of the universe, life, and earth is Intelligent Design which differs from special creationism. Conversely, Intelligent Design refers to the idea that the universe and complex biological structures could not have evolved by natural processes; they must have been designed by supernatural powers. Importantly, supporters of this approach agree that the earth is older than 10,000 years and that the created structures have been changed (Scott, 2009; Reiss, 2008; Matzke, 2010).

Moreover, part of the conflict is how religion influences people's standpoints towards science. Whilst such argumentation is ongoing, Scott (2009, p. 291) addressed the issue of evolution and creationism by questioning fact and theory, most notably by criticising scientists who claim that 'evolution is fact', whilst highlighting the definitions of theory and fact. This could be an important element of teaching and learning about evolution in science classes because in science there is no need to test facts, while theory is more about explaining natural phenomena using a logical framework of facts and hypotheses.

Although religious beliefs are a part of individuals' lives, it is more important for some than for others; hence, it may have strong influences on their lives, their standpoints regarding factors that are aligned with or against their religions, their learning, their teaching, their trust, and their beliefs (Jochman *et al.*, 2018). The debate about the conflict between creationism and evolution may seem to relate to believing in science on a broader level; however, on an individual level, it may be related to whether a person believes knowledge is provided by their own religion. Therefore, regarding an individual's standpoint towards creationism-evolution, it is essential that they do not set boundaries between themselves and science or religion. Building a relationship based on belief and trust with regard to science, which is central to the nature of science, is essential and part of science education. Further discussion and recommendations on addressing the science–religion interface in education, particularly regarding evolution and creationism, are provided in Section 6.2 Implications for Practice and Policy of the Conclusion chapter.

The last element of this research, ethnicity, regarding its influences on the science identity of students, forms the next topic.

2.3.3 Ethnic Identity

It is possible to see the terms ethnicity and race used interchangeably and together in the literature. However, to avoid confusion about the conceptual framework, it is useful to emphasise the distinction between these two terms and what they mean in this research. According to Fitzgerald (2018), ethnicity refers to a group of people having a shared culture, nationality, ancestry, and/or language; crucially, the appearance of individuals is not linked to ethnicity. Conversely, race refers to individuals who have common socially described appearances such as skin colour, hair texture, or facial features. This explanation of these terms helps to clarify what is meant when using each in this research, but in terms of the influences of both on students' identity development, the term 'racial/ethnic' is more useful in referring to the correlation between them. The term 'racial/ethnic' means race and ethnicity overlap; thus, an individual has both a racial heritage and an ethnic background such as being white and Irish American or being black and Nigerian American (Fitzgerald, 2018).

Fenton (2010) studied the ontology of ethnicity and questioned the assumption that terms like ethnicity refer to observable entities; these highlighted conceptualisations are constructed by observers, but their recognition as intellectual constructs does not diminish their concrete presence in society. Both ancestral history and cultural differences have been influential on ethnicity, which forms part of social identities, according to the aforementioned conceptual framework. These identities are flexible and used within certain contextual settings. This viewpoint reframes ethnicity as a socially generated subject that entails the mobilisation and creation of cultural and ancestral characteristics, rather than being seen as an unchangeable or fundamental feature. Fenton's (2010, p. 3) research highlights the significance of the notions of "imagined communities" and the "invention of tradition", suggesting that ethnic groups and countries are often socially manufactured or imagined entities. In short, Fenton highlights the socially constructed nature of ethnic identity, and the fluid and complex characteristics of ethnicity within the context of social identity. Race, nation, and ethnic group are interconnected concepts that share significant similarities, indicating that social attitudes, social groups, and cultural meanings are not totally separate or unrelated matters.

Osborne and Sandford (2003) stated that ignoring or disapproving of the existence of racial categories in society not only maintains racism but also minimises the significant influence of racialising activities or matters on various elements of social life, including philosophy. According to these scholars, social interactions are shaped by a visual establishment and this establishment is constructed by society, changes over time, and is culturally various. The visual registry, although it is a product of societal construction, has a profound effect on individual experiences and decisions, playing a key role in moulding one's subjectivity. In the theoretical context, as well as everyday interactions, all these components are seemingly related to each other.

In this research, science identity, gender, religion, ethnicity, and intersectionality are keystones; however, with all these focused elements of study, preferences for concentrating on certain characteristics may limit the study or exclude some key points. Such limitations and exclusions may be expected or planned in order to be able to design and complete feasible research. Throughout the interviews, participants frequently used the term 'culture' to explain their own or others' experiences and social positions. Whilst ethnicity might be equated with culture, norms, or values, this research acknowledges that culture is a broad and often ambiguous term that encompasses multiple intersecting social categories. For example, students' gender identities interact with their ethnic identities, or religious practices may be interpreted differently across cultures. Regarding cultural influences mentioned by participants, the term 'culture' is retained in their quotations, but their analysis is framed within the appropriate conceptual lens of ethnicity, based on Fitzgerald's (2018) conceptualisation and Fenton's (2010) ontological approach.

Rezai-Rashti and Solomon (2008, p. 184) conducted research with 36 volunteer pre-service teachers to examine racial identity in social settings; according to their findings, 'people of colour' have 'different orientations, understandings and experiences of race, racism and race privilege' in institutional settings. From this point of view, whilst teachers have their own experiences and understandings about race and ethnicity in different school settings, the attention to diversity and each different experience and understanding may challenge the aim of providing education to everyone equally. Thus, with all these differences, every experience related to science identity development will also vary; therefore, paying specific attention to the values that people have may be important and worth focusing on.

Additionally, Carlone and Johnson (2007) conducted an ethnographic study about science identity. The data were collected through ethnographic interviews with undergraduate and graduate students who comprising 15 women of colour (Latinas, Black, Indian, Asian). Follow-up interviews were conducted 6 years later. Even though the research is not one of the most recent, the categorisation of science identity with influences and shared experiences is quite important, especially with respect to understanding how the science identity development process and experiences related to science identity development are disrupted or impacted by outside factors, such as ethnicity/race of individuals and their recognition. In my research, in addition to gender and ethnicity, religion was included and intersectionality applied to illuminate overlapping influences.

Wong (2015) conducted a research to investigate students' aspirations regarding their career plan in the UK. This exploratory study was based on 46 semi-structured interviews with students aged 11-14 who were Black Caribbean, Pakistani, Bangladeshi, Indian, and Chinese. The results indicated that 30 of the 46 participating students expressed career aspirations related to science majors. These do not seem to align with current literature about stereotypical scientists who are white and male, or the underrepresentation of minority background population and/or women; however, the reasons behind why and how students want a science career or identify with science should be investigated. There may be alternative intrinsic and extrinsic motivations that should be considered to understand this specific interest in science. For example, if any parent is involved in science-related work and provides moral and financial support for their child to be a scientist; the decision to become a scientist may not be solely based on the child's intrinsic motivation.

Moreover, Johnson *et al.* (2011) underlined the fact that the high-status and minimum living wage (often a comfortable wage, at least in the American context) of scientists could be the motivation for some to have an interest in science. For instance, according to Lowinger and Song (2017) and Trytten et al. (2012), Asians value studying specific fields such as medicine, engineering, or other STEM fields; they also highlighted the existence of the stereotype that Asians are good at maths and certain subjects. The question about this gap in the literature regarding identification with science and willingness to study science is, to some extent, answered in my research.

Nevertheless, several research studies in the literature have reported that individuals with a minority background and women are underrepresented in the STEM field, and many researchers have conceptualised science identity in terms of recognition (Carlone and Johnson, 2007; Hyater-Adams *et al.*, 2018; Johnson *et al.*, 2011). Although recognition is important for both identity scholars and science identity scholars, the influence of socially constructed religion, gender, ethnicity, and science identities on individuals should be investigated in terms of interactions and intersections. Hence, for the purpose of this research, intersectionality served as an overarching framework.

To summarise this chapter, science identity has been conceptualised in various ways in the literature, and numerous researchers have sought to explore how science identity develops or has been influenced by other elements of life such as sex, gender, religion, ethnicity, race, culture, family, environments, school, education, teachers, the education system, friends and friend groups, and perhaps many others. Related to science identity or its development, I personally always think about the following quote:

“Every kid starts out as a natural-born scientist, and then we beat it out of them. A few trickles through the system with their wonder and enthusiasm for science intact.” — Carl Sagan

This quote may be criticised or agreed upon, but I match this ‘natural-born scientist’ understanding to curiosity and developing an interest, simply because not every individual has one intention, which is to become a scientist. For example, not everyone will be working in the field of science – they could develop an interest in or enthusiasm for painting, music, literature, and many more things. However, interest in other fields does not mean that the originally natural-born scientist has disappeared, and a new characteristic is developed due to the erased, or disrupted science persona. Curiosity, which reflects wonder and enthusiasm, is the key; these characteristics may align with the core characteristics of a scientist or a science person. Ultimately, however, experiences, preferences, and lives are influenced by other factors, and some are not changed or controlled by individuals except for standing strong, adjusting, and adapting. Within this complex world, which is both physical and psychological, every individual’s experiences are varied and unique. To be able to understand intersectionality, it is useful to look at it from different perspectives, with the opportunity to simultaneously take different factors into account. As stated previously, intersectionality is an approach to creating knowledge that has its roots in analyses of the lived experiences of women of colour – women whose scholarly and social justice work reveal how aspects of identity and social relations are shaped by multiple systems of power operating simultaneously (Hesse-Biber, 2007). The intersectional lens is therefore helpful in exploring interacting influences of gender, ethnicity, and religion in science identity. This is an important point in this research as it illuminates how science identity is influenced. To explore these issues, specific methods and methodology were adopted. Accordingly, the following chapter focuses on the research aim, research questions, and methods and methodology.

3 Methods and Methodology

3.1 Aim and Objectives of the Research

The main aim of this research was to investigate how students' gender, religion, and ethnicity impact their science identity through the lens of intersectionality. The conceptualisation of each element and the theoretical framework of the research are explained in the literature review chapter. The objectives of the research were derived from the main motivations, which were addressed in the introduction chapter, as well as the literature review. Within the main research aim, the objectives of the study were as follows:

- To explore the impacts of gender, religion, and ethnicity on the science identity of students by adopting the lens of intersectionality through the collection of quantitative data from students
- To understand how students experience the effects of gender, religion, and ethnicity on their science identity in and out-of-school through the intersectional lens by conducting individual interviews
- To explore how the constructed gender, religion, ethnicity, and science identities of students within the concept of obligatory and voluntary identity influence each other
- To understand the thoughts and experiences of science teachers regarding the impacts of gender, religion, and ethnicity on students' science identity, as well as their own, through the lens of intersectionality by carrying out individual interviews.

To achieve each research objective, a sequential mixed-methods design was adopted to gather and analyse data sets. This allowed me, as the researcher, to improve the data collection instruments and obtain more comprehensive data to answer the research questions. Whilst this research focused on gender, religion, and ethnicity separately, the lens of intersectionality was useful for exploring the intersecting influences of these three elements on science identity.

As the researcher, I have worked on advancing my knowledge and skills in relation to the literature on science identity, methods, methodology, data gathering, and the analysis of the data. In the literature review chapter, the main motivation for the research, critical points raised in existing sources in the light of my research topic were highlighted. In this chapter, I explain and ground my research philosophy in the ontological, epistemological, and methodological assumptions – such as beliefs about how knowledge is constructed, the nature of reality, and the appropriate methods – that underpin how the research was to be conducted.

3.2 Research Philosophy

Research is not only about data and outcomes, but also about using appropriate techniques within a chosen paradigm. Paradigm refers to the representation of broad orientations towards the world and a researcher's perception of research (Lincoln *et al.*, 2011). Furthermore, the paradigm guides research methods and methodologies as an overarching framework (Braun and Clarke, 2019). Related to paradigms, two foundational elements, ontology and epistemology, are essential for understanding the broader philosophical approach. Therefore, a brief exploration of ontology and epistemology is useful before discussing the paradigm adopted in this research.

Ontology and epistemology provide insights into what the researcher believes to be the nature of truth, the nature of the world, and ways of being in that world; all these describe the worldview of the researcher (Berryman, 2019). Regarding ontology, Braun and Clarke (2019) asserted that the link between the outside world and how we as humans understand and behave is defined by ontological viewpoints; the question of ontology determines whether we believe that reality exists independently of human beliefs and practices. Additionally, there are two approaches related to the existence of reality in ontology. The first, a realist approach, claims there is only one reality; the second, the relativist perspective, asserts that there are multiple realities (Braun and Clarke, 2019).

According to Crotty (1998), being human is an essential component of the system, and relativist ontology is based on the philosophy which claims reality is constructed within human minds. Thus, reality is relative to how individuals experience it in a certain context (Braun and Clarke, 2019). In this research, the approach of relativism was the source for conceptualising the research themes and enhancing my understanding of how the science identities of students vary with the influence of their other identities. For example, beliefs in religion, developed gender identity, and the ethnicities of each student can be crucial aspects of their lived experience, influencing their own identification and desired recognition. Nevertheless, personal perceptions are not independent ideas created by individuals, they are also shaped by values or societal elements. However, values or societal elements are also human-based phenomena. Humans actively interact with and experience their immediate surroundings, and individuals' understanding of the essential aspects of life is shaped by these interactions (Crotty,1998).

The second important concept related to research philosophy is epistemology. According to Sprague (2010), epistemology describes ways of knowing, how we know what we know, and who can be a knower. In essence, epistemology is concerned with how people understand and investigate the world, as well as the reasonings that are employed in order to support their knowledge (Greene, 2008). Epistemology covers two main viewpoints: realism and relativism. Realism claims that truth can be obtained through the production of valid knowledge, whilst relativism argues that knowledge is naturally subjective and influenced by different perspectives, making it theoretically impossible to attain a singular, absolute truth (Braun and Clarke, 2019).

Ontology and epistemology are related to one another; in the context of understanding how ethnicity, religion, and gender identities influence science identity, the stance of ontology was helpful in providing a more comprehensive understanding of identity dynamics as well as the complex nature of human dynamics, with the premise that individuals are not isolated from both physical and social environments. In the context of epistemology, the epistemological standpoint adopted in this research guided the selection of the methods for data collection, the overall research design, and carrying out the entire research to accomplish the objectives and answer the research questions. Thus, it was necessary to employ appropriate methods to explore how gender, religion, and ethnicity influence students' science identities.

After reviewing the ontology and epistemology, it is fundamental to clarify the notion of paradigm within this research context. A paradigm serves as the overall framework that guides the interaction between our understanding of reality and the methodologies used to investigate reality. Various paradigms exist, such as positivism, postpositivism, advocacy/participatory, pragmatism, and constructivism (interpretivism).

According to Cohen *et al.* (2018), positivism is based on a straightforward correlation between external reality and humans' subjective understanding of the existing reality; this is close to the philosophical framework of empiricism. The validation of reality by objective and neutral data gathering is crucial in positivism (Assalahi, 2015). Collecting reliable data to use in research based on the positivist paradigm can be achieved by utilising scientific methodologies which effectively control variables and eliminate the various harms or biases (Braun and Clarke, 2019). The usage of appropriate methodology will enable the research to achieve the aim related to the discovery of objective reality.

Postpositivism is a follow-up philosophical perspective on positivism. It criticises the positivist understanding of an unquestionable reality given the uncertainty of human behaviours and actions (Phillips and Burbules, 2000; Creswell, 2010). According to scientific methods based on the postpositivist paradigm, the process of questioning begins with theory and then moves on to the collection of data which could support or reject the theory, following which examination and revision are needed before further tests are conducted (Cohen *et al.*, 2018).

The third paradigm is the advocacy/participatory paradigm, which is based on the exploration of systemic oppression and the lack of voice whilst stressing the needs of individuals who belong to underrepresented or marginalised groups or societies (Cohen *et al.*, 2018). This paradigm criticises the postpositivist approach's strict laws and theories, which are not applicable to situations such as disadvantaged people and/or social justice issues (Creswell, 2010). When this paradigm is adopted in research, the research focus is related to politics and includes a strategy for transformation and action.

Pragmatist scholars adopt a perspective that does not see the world as a unified entity by nature (Creswell, 2010). Pragmatism places significant emphasis on the investigation of the study topic and employs several methodologies to address the research question(s) (Cohen *et al.*, 2018). Consequently, researchers use a combination of methodologies in order to obtain a more in-depth understanding of a given subject. Furthermore, researchers highlight the importance of research conducted within social, historical, political, and other contextual frameworks, thereby facilitating the examination of various methodologies, diverse perspectives, underlying assumptions, and diverse approaches to data gathering and analysis (Cohen *et al.*, 2018; Creswell, 2010).

The final paradigm to mention, constructionism (also known as constructivism) is a term that generally represents the interpretivists' philosophical stance (Assalahi, 2015; Cohen *et al.*, 2018). It provides a critical perspective on the notion of knowledge as an objective representation of reality (Cohen *et al.*, 2018). This paradigm claims that understanding of the world is impacted by various elements, their interplays, and systems of meaning that are present in the social environment of individuals. The constructivist perspective argues that instead of a single and absolute concept of knowledge, several forms of knowledge could emerge as a result of the development of meaning through time. Moreover, knowledge could be viewed as social structures which integrate various dimensions such as social, cultural, moral, ideological, and political settings (Creswell, 2010; Braun and Clarke, 2019). Therefore, knowledge is not just a final product, it could also be an outcome of interpretations and understandings. For example, an investigation about an individual's various personalities comes from the theoretical conceptualisation of studies about personalities, rather than assuming personality is not an inherently objective truth (Cohen *et al.*, 2018; Braun and Clarke, 2019).

In terms of paradigms and their approaches, there are two generic terms which refer to their standpoints, normative and interpretive. Whilst normative paradigms are based on rule-governed human behaviours that could only be investigated using scientific methods, interpretive paradigms examine the subjective experiences of humans in order to understand them (Cohen *et al.*, 2018). For example, Taylor and Medina (2013) used the interpretivist paradigm in their educational research, claiming that it allows researchers to investigate the complex experiences of educators and learners. This permits a detailed understanding of different backgrounds and dynamics in educational environments, ranging from classrooms to broader community contexts. Interpretivism mainly focuses on investigating individuals' actions and meanings through non-statistical methods. Therefore, qualitative methods and subjectivity are relied upon in an interpretivist worldview. However, mixed-methods research could be designed with an interpretivist paradigm to combine qualitative and quantitative research in order to investigate the subjective experiences of individuals and the broader context in which those experiences occur.

Thus, to examine how individuals experience and interpret the complex interactions between gender, religion, and ethnicity, and their impacts on students' science identity, the constructivist paradigm was adopted in my research. As the researcher, upon studying various paradigms, the dynamic process of knowledge construction based on the constructivist paradigm appeared more useful than the assumption of objective truth that exists independently according to normative paradigms. As conceptualised previously, identities are not only created and influenced by internal variables, but they are also affected by external circumstances. This approach allows research to be designed which focuses on the diverse and complex nature of individual and societal dimensions, as well as an understanding of how these dimensions intersect, mutually influence one another, and are subjectively interpreted by individuals within the context of their personal experiences.

When rationalising the adopted paradigm in the research, determining a single appropriate approach is a challenging task. Clearly, because of the knowledge sought in this research, the use of positivism was not suitable because of its association with the belief in an objective truth. My research aimed to explore the effect of complex interplays of individuals' identities on their science identities whilst taking their experiences and some variables into account. Therefore, constructivism was a potentially appropriate approach to use, especially regarding understanding participants' experiences of how their science identities are impacted by their gender, religion, and ethnicity within the social environments in which they are situated. Whilst investigating the research topics, because of the lack of definitive answers which are true for everyone, the outcomes could be relative due to various influences such as family, relatives, and friend groups, as well as their experiences in school settings. By stating my positionality in adopting the constructivist paradigm, whilst taking into account the inherent complexity and variety of these interconnected instances of identities, I was able to conduct a comprehensive research study to understand how students' gender, religion, and ethnicity impact their science identity.

3.3 Mixed-methods Research

Mills and Gay (2016) described mixed-methods research as involving the collection, analysis, and utilisation of both quantitative and qualitative research designs to understand the research problem. Both qualitative and quantitative data collection provide, to some extent, a more complete picture of the research problem than would have been possible through the collection of either type of data on its own. A mixed-methods approach also enables reliable data to be obtained and provides a greater understanding of the context related to this topic (Johnson *et al.*, 2011).

The idea of complementarity is the main purpose for using mixed-methods research. According to Ary *et al.* (2014, p. 591) "complementarity involves seeking elaboration, illustration, enhancement, or clarification of findings from one method using results from another. Different approaches are used to measure different facets of a single phenomenon". For example, the collection of quantitative data on science identity enabled me to get to know/see the big picture about students' science identity and other identities; this sort of data was then utilised with qualitative research in order to explore the thoughts of different students who have various religious, gender, and ethnic identities, and experience different social environments and lives. With a qualitative approach, in-depth information can be collected from a small number of students to generate answers as to the why(s) and how(s) regarding specific contexts. Mixed-methods research encompasses two overarching methodologies, each with several variations concerning the application of data collection methods and the aims of research.

3.3.1 Concurrent Mixed-methods Research

Concurrent mixed-methods involve merging or converging quantitative and qualitative data to provide a comprehensive analysis of the research problem; this design involves collecting both forms of data simultaneously, and then integrating the data to provide an overall analysis (Cohen *et al.*, 2018). Additionally, a smaller form of data may be embedded within another data set to analyse different types of questions. In this design, the qualitative method may address the process, whilst the quantitative method may address the outcomes (Creswell, 2010). When considering concurrent mixed-methods research, there are potential modifications that may be used to enhance the appropriateness of the chosen technique. Two such variations include the concurrent triangulation approach and the concurrent embedding strategy. The concurrent triangulation approach, which is a common mixed-methods model, is used to compare these approaches to determine convergence, differences, or combinations. This method is often used to minimise weaknesses in one method through the strengths of the other. The concurrent embedded strategy of mixed-methods involves collecting both quantitative and qualitative data simultaneously during a single data collection phase. This may allow researchers to obtain a new viewpoint or understanding from various data. The main limitation of this type of mixed-methods approach may be data transformation; the data needs to be appropriate for integration and analysis.

3.3.2 Sequential Mixed-methods Research

This type of strategy involves using one method to build on or expand the findings of another. For example, a qualitative interview may be used to explore a research question, followed by a quantitative survey method to generalise the results to a larger population. Alternatively, a study may begin with a quantitative method to test a theory or concept, followed by a qualitative method to explore the topic in more detail with a smaller number of cases or individuals (Creswell, 2010; Cohen *et al.*, 2018). Regarding the sequential mixed-methods strategy, a sequential explanatory strategy is one of the variations to adopt; another is the sequential exploratory strategy. For the sequential explanatory strategy, quantitative data are gathered and analysed first, and then qualitative data are collected; this sequencing is used when unexpected or unclear results arise from the quantitative study, and allows for detailed examination of data (Creswell, 2010). By contrast, the sequential exploratory strategy also consists of two phases, but here the first phase involves the collection and analysis of qualitative data, and the second phase involves gathering quantitative data; this strategy is helpful in using quantitative data to understand more from the qualitative data phase. The sequential mixed-methods research design is appropriate to use in contexts such as testing new ideas, working out the distribution of focused phenomena, and developing new research instruments (Creswell, 2010; Cohen *et al.*, 2018).

Although the concurrent mixed-methods strategy was a viable option, the sequential mixed-methods design was more appropriate for the development of the data collection instrument and time suitability of students and teachers in schools. To investigate the potential effects of gender, religion, and ethnicity on students' identities, the data were gathered through teacher interviews, a survey completed by students, and student interviews. The primary emphasis of this study primarily remained the science identity of students, yet the first group of participants was science teachers. The rationale for prioritising the collection of data from science teachers was that science identity is conceptualised in various ways; there is no certain description of science identity. Therefore, when studying three other elements and the non-precise science identity concept, I believed that the experiences, thoughts, and any sharing from teachers would be helpful in improving the data collection instruments applied to students. In addition, existing studies benefited as sources of information and to ground the research design. For example, a study conducted by Chang *et al.* (2011) examined the effects of racial stigma and science identity on university students through longitudinal surveys conducted by UCLA's Higher Education Research Institute. Similarly, Stets *et al.* (2017) conducted research on the relationship between science identity and pursuing a career in science using a quantitative method. They focused on students moving from one institutional setting (schools) to another institution (economy) and how science identity influenced going to the economy related institution.

In a different study, Bøe (2023) explored how the culture of achievement impacts the engagement of high-achieving physics students; the research, conducted through longitudinal interviews, aimed to investigate how students' efforts to be successful in challenging tasks contributed to a culture of achievement. However, cognisant of the nature of each research design aim and design uniqueness, my research adopted both survey and interview data collection methods to investigate how science identity is impacted by gender, religion, and ethnicity.

Using the survey method, data were collected from more than 100 students in a school on how they think, experience, and value their science identity, gender, religion, and ethnicity. For interview participants, their experiences in relation to science identity and how it is influenced by them were understood in detail. In short, there have been many studies conducted with large participant populations, but this study as a PhD project conducted by one researcher required substantial time and effort management, as collecting quantitative data from a school with over 100 students as participants was a significant undertaking that necessitated careful planning and coordination.

By implementing mixed-methods research, using both qualitative and quantitative data collection provides a number of advantages. The first advantage is that each method assists in developing a more comprehensive and purposeful data collection tool; secondly, the strengths of some methods overcome the weaknesses of the others for the purpose of minimising, as much as possible, potential error or bias within resource and time constraints. One of the advantages of mixed-methods research is that it focuses on the whole and its constituent parts, and the causes of effects (Cohen *et al.*, 2018). Another advantage is that a mixed-methods research design counterbalances multiple methodological approaches that provide variety and difference and are “anchored in values of tolerance, acceptance, and respect” (Greene, 2005, p. 208).

Despite all these advantages, mixed-methods research also has some disadvantages. First, the researcher needs to understand the complexities of both qualitative and quantitative research in order to make correct decisions as to how to mix both types of research. The second disadvantage is that conducting mixed-methods research needs more time, effort, and expense. Furthermore, the researcher can face the difficulties of both qualitative and quantitative research. Analysing and interpreting conflicting results can also be challenging (Ary *et al.*, 2014).

Nevertheless, using mixed-methods research design was deemed more useful because the complex nature of science identity might have caused some difficulties in the development of measurement tools. Qualitative or quantitative research has already been conducted to investigate science education and/or science identity. For example, Vincent-Ruz and Schunn (2018) conducted research using a quantitative method on the science identity of 7th and 9th grade students in the US. The students stated that they had developed science identities differently, and that their science identities play a complex role in making gender specific choices, which was particularly critical for girls. Another quantitative study was conducted by Chen *et al.* (2020) to test the correlation of gender-matching between students and their first high school science teachers in terms of developing a stronger science identity. The findings revealed that although there was no association for physics, in chemistry there was an effect of gender-matching for girls, and for biology it was influential for both genders. A stronger science identity and gender match effects could be beneficial for minority students because it increases their feeling of belonging. With these valuable results, the quantitative data provide information about some certain questions, but qualitative data could have helped to provide more detail on the differential effects of gender, at least for some participants. For example, having completed quantitative data analysis, the question about why physics and gender-matching effects are different from others could have been asked. Despite not aiming to answer questions such as how science identity and a sense of belonging correlate, or how a strong science identity increases the feeling of belonging among minority students, these questions could have been raised from the findings of this research. However, these questions, which have not yet been answered, could be answered in my research, not only because of the overlapping research topics but also due to the appropriate research design.

Archer *et al.* (2010) conducted an initial study as part of a 5-year longitudinal study to explore how the interest of students in science and their scientific career plan changes over time. The study was undertaken by conducting six focus group discussions with 10–11-year-old students. While the qualitative basis of the study provided an understanding of what students think about doing science vs becoming a scientist, the key aim of the research was to create a distinction between why a student enjoys science and why the student may not want to work in a science-related field or be a scientist in the future. However, in my research, the most important point to highlight is that the enjoyment of science among students and the level of unwillingness to study science in the future was influenced by their identities and shaped by religion, ethnicity, and gender. Although the key themes of my research are different from the study of Archer *et al.* (2010), my study highlighted the influence of intersections and interactions of other identities, and also multifaceted identity.

Therefore, in addition to the studies mentioned above, my research utilised multiple methods of data collection to address the gaps that correlated with my research objectives and questions. Furthermore, by focusing on science identity and gender, science achievement and being from a minority background, or science identity and science career plan, my research contributes to the existing literature by studying different groups of people and gathering diverse types of information. Because the above studies were conducted some time ago, a number of significant points were emphasised, but more research is required to provide the science education field of literature with additional details.

Overall, numerous studies have been conducted in the field of science identity with various perspectives/lenses and different methods applied. However, the important aim of my research was to explore the science identity of students and how this is influenced by religion, gender, and ethnicity through the lens of the intersectionality framework by adopting mixed-methods research. This is an approach that combines qualitative and quantitative research methods to gain a more comprehensive understanding of the phenomenon of science identity. Furthermore, by using a combination of quantitative and qualitative data, mixed-methods research can enhance the validity and reliability of findings.

As mentioned previously, my study approach comprised a sequential mixed-methods design; the first step involved gathering data from science teachers through interviews; the second step consisted of collecting data from students by survey; and the final part of data collection involved conducting interviews with students. There were two main reasons for beginning data collection with teacher interviews. Firstly, teachers are consistently present and engaged in observing various situations related to science and students. Such situations cover science interest, identification, recognition, displayed enthusiasm, confidence levels, and even career aspirations. The second reason is that the data collection instruments applied to students could be improved through the process. In light of the fact that teachers have a unique perspective, the information obtained by conducting interviews with them provided a useful lens through which to obtain a deeper comprehension of students' scientific identities from a different point of view.

In order to devise good research methods and methodologies, and effective ways to collect data, the first step was to conduct a thorough review of the existing literature on the idea of being a science person, the formation of a science identity, the idea of being a science person and having a science identity, and the factors that may have influenced the development of a science identity or the idea of being a science person.

A detailed breakdown of the subthemes included in the teacher interviews, student questionnaire, and students interviews as well as the literature sources utilised to inform their inclusion, can be found in Table 1. Table 2 provides a comprehensive overview of the steps undertaken in the development of the questionnaire, as well as the underlying purposes of each of these steps.

Table 3 Subthemes of questionnaire and resources that were beneficial in designing data collection instruments

Subthemes	Resources
Voluntary and Obligatory Identity	Burke and Stets, 2009 Gallagher, 2016
Science Identity	Archer *et al.*, 2015 Avraamidou, 2014b Avraamidou, 2019a; 2019b Byars-Winston and Rogers, 2019 DeWitt *et al.*, 2016a Jackson *et al.*, 2019 Jochman *et al.*, 2018 Salehjee and Watts, 2020 Vincent-Ruz and Schunn, 2018
Religion	Gondwe and Longnecker, 2015 Jochman *et al.*, 2018 Taber *et al.*, 2011
Gender	Avraamidou, 2019a; 2019b

School Science Education	Avraamidou, 2014a Gondwe and Longnecker 2015 Jackson *et al.*, 2019 Archer *et al.*, 2015
Science Education Related Organisation (except schools)	Archer *et al.*, 2015 Avraamidou, 2014a Jackson *et al.*, 2019

Table 4 Steps and purposes in creating the questionnaire

Steps	Purpose
Conduct a literature review	To understand how science identity is conceptualised by authors and researchers. Also, prior research and beneficial theories in my research field served as resources to identify existing survey concepts/items and determine what kind of questions could be asked of participants.
Create the first draft of the questionnaire	To discuss this with supervisors to meet the demand of collecting appropriate data for the designed research. To ensure items are clear, understandable, and written in accordance with the designed research approach.

Synthesise the literature review and outcomes of discussion with supervisors	To ensure that the conceptualisation of the construct makes theoretical sense to scholars in the field.
Develop questions for the questionnaire	To ensure items used to collect data serve the purpose of the research, and to revise language use and content.
Get confirmation from supervisors as expert validation	To assess how clear and relevant the items are with respect to the designed research. Also, to agree with supervisors the applicability of the survey.
Conduct pilot study	To ensure that respondents interpret items in the manner intended. To check for adequate item reliability and validity with respect to other measures. To test the feasibility of the research methods and identify any potential issues or challenges that may arise during the full-scale study so as to address these in advance.

To ensure the validity and reliability of data collection, it is important to test data collection tools. Therefore, the data collection instruments that were used in this research were tested through a detailed pilot study process. The pilot study details are explained later in this chapter but, in short, a pilot study is a small version of the designed research that involved applying the sequential mixed-methods with a specific aim of benefiting from each phase’s outcome to improve the data collection instruments. However, before moving on to the pilot study process, validity and reliability are the next topics as they are important issues regarding the methods employed in the research.

3.4 Validity

According to Shaw and Crisp (2011), there is no single accepted definition of validity, which is a highly debated subject in educational and social research. However, validity could be described as referring to whether a data collection instrument measures what it intends, purports, or claims to measure (Winter, 2000). There are various forms of validity; for example, a fundamental form is construct validity (Cohen *et al.*, 2018). This, according to Loevinger (1957, cited in Cohen *et al.*, 2018), is the 'queen' of the different types of validity as it encompasses other types and is concerned with constructs or explanations rather than methodological aspects, such as the meaning, definition, and applicability of elements. Construct validity compels the researcher to seek counter examples that could invalidate their construction, in addition to checking that the construction aligns with that offered in the relevant literature or the consistency of measurements of the construct is in accordance with other measures of the same construct (Cohen *et al.*, 2018).

To establish the construct validity of my research, I had to be confident that the construction of a particular issue was justified. The research components, focused elements, and content of the data collection instruments used in my research were justified, and that they were consistent with other constructions and theories related to similar research topics in literature. I designed the data collection tools with careful attention, completing a comprehensive literature review and utilizing extensive academic resources, as outlined in the table: Subthemes of the questionnaire and resources that were beneficial in designing the data collection instruments. Additionally, the supervisory team, as experts in the fields, provided valuable insights and development opportunities. Each version of data collection instruments was tested in detail with individuals who were not part of the main research sample. However, the pilot study participants were similar to potential main research participants in terms of diversity regarding gender, religion and ethnicity. The pilot study participants were the students of similar age and science teachers. The detailed piloting process is explained later in this chapter.

3.5 Reliability

Reliability refers to the consistency and repeatability of data collection tools in terms of whether they could be used over time and across groups of respondents (Cohen *et* *al.*, 2018; Williams, 2003). Certainty and accuracy are important in reliability (Cohen *et al.*, 2018); therefore, it is important to ask questions such as: Are the results reliable? Can we believe these results? Such questions are important because reliability is a significant parameter for the value of findings. For example, some characteristics, such as height, can be measured exactly, whereas others, such as the importance of gender for someone, cannot be measured with a certain value. Two areas of reliability should be evaluated when using self-complete surveys. First, researchers may measure test–retest reliability by having respondents complete a questionnaire twice about two to three weeks apart, provided their circumstances have not significantly changed within this timeframe (Williams, 2003). For research to be reliable, similar results should be found if another similar study were conducted with a similar set of respondents within an alike context. Second, the internal consistency of a research instrument can be tested by asking the same question(s) in different ways throughout the questionnaire/interview. The replies may then be compared, just as previously.

To test validity and reliability in my research, a pilot study was conducted in three phases. The key purpose of the pilot study with regard to validity was to investigate the construction of the research, and whether the instruments measured the key elements, as intended. With respect to testing the reliability of the instrument, three of the students were participants twice for the quantitative part of the research and one of the students was invited for two interviews. There were two main purposes to performing the test-retest; one was to discuss the questions and their improvement; the other was to see whether students answered in the same/similar way to questions that were not changed during the piloting of the data collection instruments. Also, in terms of controlling internal consistency, some questions were rephrased and asked twice or in different ways.

3.6 Pilot Study

3.6.1 Background and Aims of the Pilot Study

A pilot study is an important phase of a research that serves to eliminate potential problems, practise data gathering, and improve the research tools and process. Pilot study, also known as a feasibility study, represents the mini version of the larger research, which includes preliminary testing of research tools such as interview questions or surveys, and the process of practising (Van Teijlingen and Hundley, 2002; Doody and Doody, 2015). Another advantage of a pilot study is that researchers may face ethical issues that may appear during the main research and can identify ways to handle them within appropriate ethical guidelines. Therefore, a proper research design can be developed with the help of a pilot study.

A pilot study can also be used to justify a research design before conducting the main research and is also vital for time management. Despite my main research design being somewhat different from what I was able to perform in my pilot study, my intention in conducting the pilot study was to test the data collection instrument and the data collection procedures, and to deal with ethical issues that arose prior to the main research proper. Therefore, the number of participants in my pilot study was small.

The pilot study phase was conducted with students who were contacted through personal networks. The reason for the differences in context of the pilot study is that there was limited access to schools because of the ongoing, long-lasting effects of COVID-19. The supervisory team agreed to not conduct the pilot study in the school where the main research would be conducted. However, because this school has a diverse structure, diversity was an important criterion during the pilot study for participating groups of students and teachers. During this phase, interviews with teachers, administering the survey to students, and interviews with students were practised; also, research tools were revised to ensure the acceptability, validity, and reliability of measures. Each method and relevant group piloting details are given as follows.

3.6.2 Piloting Individual Interviews with Science Teachers

The process of piloting teacher interviews was conducted with two individual science teachers. Teachers' consent for their voluntary participation, to be audio recorded, and the possibility that their responses would be used for academic publication were obtained. Before starting each teacher interview, I explained that this was a pilot study and encouraged them to ask questions or share their comments. The testing process was helpful in revising existing questions. For example, the first few questions were confusing because both teachers asked questions such as "Did you ask this question about myself or about my students?" Therefore, I decided to divide the interview questions into two sections, and also gave instructions to make the following questions clearer for teachers or for students. Also, some questions were occasionally asked again to ensure clarity and to collect more information. This was also useful in obtaining more information because one of the teachers said, "We talked about it, but when you asked this again, this made me think this again, I was like there is something related to this, such as while teaching science, I tried to be gender-blind, but talking about religion, or ermmm, race, or ethnicity made me think like being gender blind is not always helpful because if students need more encouragement". As a result, both teacher interviews and piloting were well received and valuable.

3.6.3 Piloting Questionnaire with Students

The student questionnaire was designed to ask questions about their demographic background, religion, gender, ethnicity, and science identity. The piloting process for the questionnaire consisted of three sets to ensure clarity, reliability, and validity. After providing information sheets, consent was obtained from both parents and students. All necessary information was explained before starting testing, such as anonymity or being audio-recorded.

The first set of the pilot study involved two students, one male and one female. The first test of the survey was to ascertain whether the questionnaire was easy to understand and to gather students' thoughts while filling it out. The questionnaire had 28 questions, divided into two sections. The female student found the questions understandable. However, the voluntary and obligatory identity part was boring for her. Moreover, the male student expressed his liking for science lessons, and so he liked the first part including questions for science. However, when he saw an explanatory text about voluntary and obligatory identity, he did not want to fill in that part.

After revising the first version of the questionnaire, the second version was tested with five female and two male students. The text for the explanation of obligatory and voluntary identity had been shortened before the second attempt, but all participants in the second set of piloting agreed that they disliked reading that text. Due to their comments on that text, I had a chance to talk with students and revise the text and questions. As a result, the questions related to voluntary and obligatory identity were rewritten, and the text was removed; also, some questions about gender and ethnicity were revised.

During the third test of the survey, four female students and one male student completed the questionnaire. Two of these students were participants from phase two, and one was participant from phase one. Overall, students shared thoughts about the questions that were clear; they found it easy to answer because of the order and design. Also, the three students from phase two commented that the survey was better without the text relating to voluntary and obligatory identity. As a result, the final phase proved that piloting and revising the questionnaire were useful in developing an effective questionnaire for use in the main research.

3.6.4 Piloting Individual and Group Interviews with Students

The interviews with students were piloted by comparing two methods: individual interviews and group interviews. Students and their parents were provided with information sheets, and consent was gathered from all participants and their parents. Three students voluntarily participated in individual interviewing and four students in group interviewing. One of the students who was interviewed individually also participated in the group interview piloting. Before starting the interview, key points were explained to the participating students; also, I encouraged them to share their thoughts and ask questions about anything they did not understand. The outcomes of piloting were that the individual interviews allowed me to gather clear and focused answers. Additionally, I was able to ask more questions easily to investigate deeper information related to topics. However, group interviews also provided detailed data due to the friendly environment and peer interaction. The difficulties of group interviews were that sometimes students did not listen to each other, but talked over one another instead; therefore, sometimes asking more questions was not easy. Also, when transcribing data, the audio recording made it challenging to distinguish who was speaking at a certain time; consequently, there were far more points missing in group interviews than in individual interviews. The testing was helpful in deciding whether interviews should be conducted individually. Additionally, I had the chance to talk with students about their criticisms of the questions asked during the interviews. Some stated that questions were understandable, and some were fun to talk about; however, one student suggested reducing the number of interview questions. The last outcome of the piloting of interviewing was that students' understanding of science could differ, such that they could either think 'science' as either general science or school science lessons. This finding would be added to the questionnaire to see whether there was any difference between students' understanding of science and having a science identity. To conclude, piloting the process was useful for developing research tools, practising the process, and addressing ethical issues.

3.7 Sampling Strategy

In the social sciences, a sample refers to the group of people who participate in the research and were chosen according to the adopted methodology. The main purpose of sampling is to gather accurate, reliable, and unbiased data from the target population, as well as to increase efficiency and decrease effort (Schofield, 2006). In this research, a mixed-methods approach was adopted to focus on a specific group of participants; namely, science teachers and Year 10 students in a secondary school in London. According to Simons (2009) and Thomas (2013), the case study methodology is useful for conducting a detailed investigation from multiple perspectives in a real-life context; this aligned with the aims of my research. Although my research does not constitute a formal case study, it involves an in-depth exploration of the complex influences of gender, religion, and ethnicity on the science identity of students through the lens of intersectionality. The school where the research was conducted was the case, and the unique experiences and beliefs of students and their science teachers, as well as the influences of their social environments regarding the research focus were examined. By employing both a mixed-methods approach and a case context, this research achieves an in-depth exploration within a bounded and complex system (a school with components such as students and teachers) by collecting qualitative and quantitative data and integrating them to generate a comprehensive understanding of the research topic.

In this study, convenience sampling was the main sampling method. The convenience sampling method is cost-effective; potential participants are geographically accessible to take part in research and have an inclination to participate voluntarily (Robinson, 2014; Suri, 2011). Whilst the main sampling method was convenience sampling, snowball sampling served as a useful alternative, especially for the qualitative part of this research. Cohen *et al.* (2018) stated that snowball sampling could be used to ease the contact and recruitment of groups which are difficult to study. Hence, in the event of a low number of participants for a specific part of the research, the snowball sampling method would help to increase the number of participants. For example, potentially participants could act as informants to identify other individuals and assist the researcher with easy communication.

During the research, it was important to follow the sampling method in an appropriate way to access participants; the process for getting in touch with potential participants is a phase to be careful of, especially with respect to ethical considerations. Therefore, as a first step in contacting the school, personalised emails were created to send to headteachers, administrative staff, and teachers individually. The email included a brief explanation of the research, an invitation to participate, and an attached information sheet which provided further details. The email was sent to around 100 schools, but many did not respond. A large number stated that they did not want to participate because of COVID-19 restrictions and the pandemic's long-lasting effects on education and students. Fortunately, three schools expressed an initial willingness to take part in the research, but two schools later expressed their regret at not being able to participate due to teachers' schedules and students' lack of interest. As a result, one school became the primary participating school. Having received confirmation of the science teachers' willingness to participate, the information sheets for students and their parents were sent to inform them about my research and thereafter request their confirmation through written consent forms to allow students to participate in the survey and interviews.

Once consent had been obtained from participants and students' guardians, the data were gathered from a secondary school located in the London Borough of Harrow. Harrow, situated in the north-west region of London, exhibits cultural heterogeneity as it includes individuals who are from black and minority ethnic backgrounds, with a substantial percentage of Indians. Additionally, this area is a religiously diverse location that is home to Hindus, Muslims, and Jews (Office for National Statistics, 2021). The diversity of Harrow can also be seen in the school setting, as the school has students from a wide range of ethnic, and religious backgrounds. The diversity of the area and the school creates a unique environment for students and teachers. For students who are in the process of developing a science identity, such a diverse environment might provide opportunities to experience the complex interaction of personal beliefs, cultural values, and educational practices. Therefore, in terms of the influences of students' gender, religion, and ethnicity on their science identity, the data collected from this diverse school were comprehensive and included various perspectives derived from the experiences of science teachers and students.

The school provides education to students aged 11 to 18. The enrolment demand is high; therefore, entrance to the school can be competitive, but this influences the academic environment and peer dynamics. The main research data were gathered from voluntary science teachers and Year 10 students. This particular group was chosen based on their developmental stage, as students in Year 10 have greater cognitive maturity compared with younger students. In terms of deciding which students could participate in the research, discussions were held with their science teachers, and they recommended conducting research with Year 10 students because Year 11 students would be concerned about their preparations for tests and the demands of educational responsibilities, which might have affected their interest in engaging with research. Furthermore, Year 10 students can exhibit a level of cognitive development that allows them to comprehend and reflect on intricate subjects, including but not limited to gender, religion, ethnicity, science identity, identity, cultural values, and religious values. Thus, the students involved possessed a fundamental comprehension of scientific ideas, methodologies, and principles, enabling them to productively interact with the survey material. Also, the practical advice of science teachers was based on the idea that younger age groups would be reluctant to participate because of their developmental status and level of knowledge about the research topic

The first phase of the research involved gathering data from seven science teachers using semi-structured interviews. The second phase of data collection consisted of administering surveys to students in Year 10, and the final phase involved gathering data from five students through semi-structured interviews. The details of each phase are explained in the following parts.

3.8 Data Collection and Initial Analysis

The sampling process, obtaining consent, and the data collection process were explained previously. The data collection design consisted of three phases: the first phase consisted of conducting interviews with science teachers to answer related research questions and enhance quantitative data, as per the aim of employing a sequential mixed-methods research design. In Phase 2, the survey, developed earlier and revised with insights from the teacher interviews in Phase 1, was administered to students to gather data about their science identities and the factors influencing them. The limitations of the survey regarding the details of students' experiences and thoughts were explored through student interviews in phase 3.

3.8.1 Phase 1. Collecting Qualitative Data from Science Teachers Through Individual Interviews

The first phase of data collection was based on interviews with 7 science teachers, 2 male and 5 female teachers, who volunteered to participate. A semi-structured interview format allowed me to ask additional questions to enhance the collected data. The outcomes of the interviews were represented as themes and codes capturing what the science teachers shared.

To ensure privacy protection, the names of science teachers were anonymised. The anonymised names represent teachers' diverse backgrounds and values. Information about teachers' ethnic and educational backgrounds, and the specific science subjects they teach are as follows:

Table 5 Overview of teachers' gender, religion, ethnicity, educational background, and specialised subjects

Teacher's name	Gender	Religion	Ethnicity	Specialised subject	Years of teaching science experience	Degree(s) obtained
Johan	Male	No religious or spiritual beliefs	White	Chemistry	More than 2 years	Undergraduate degree in natural and social sciences (an interdisciplinary degree in the Netherland) PhD in chemistry
Emily (Head of Science)	Female	No religious or spiritual beliefs	White	Chemistry	More than 10 years	Undergraduate degree in biochemistry
Neha (Curriculum leader in science department)	Female	Sikh	Asian	Physics	More than 7 years	Undergraduate degree in science, physics, and music
Ethan	Male	Judaism	White	Biology	11 years	Undergraduate degree in zoology and psychology

Lucia	Female	Agnostic	White	Chemistry,	3 years	Undergraduate degree in science and technology applied to cultural heritage (in Italy) PhD in chemistry
Sara	Female	Islam	Mixed ethnicity	Biology	4 years	
Leila	Female	Islam	Asian	Biology	More than 13 years	Undergraduate degree in medical microbiology

The themes that were created from the data gathered from science teachers also represent the conceptualised elements of science identity. The four fundamental themes of science identity are: identification and recognition as a science person, science interest, confidence in science, and a career plan in science. Regarding these themes, codes represent more detailed findings from the gathered data; for example, being interested in or passionate about science or being critical and questioning. Furthermore, the interaction of components of the research, such as gender, religion, and ethnicity, with the conceptualising elements of science identity is given as a sub-theme under each relevant theme. Moreover, the findings related to the intersections of gender, religion, ethnicity, and science identity also serve as one of the themes.

3.8.2. Phase 2. Collecting Quantitative Data from Year 10 Students by Questionnaire

In phase 2, the survey was administered to Year 10 students, and it received a response from 145 students. However, not all of the Year 10 students participated, either because some students' parents did not give their consent, or some students did not want to take part in the research. Among the participants, 64 were male, 70 were female, 3 were non-binary, and 5 chose 'prefer not to say'. The questionnaire consisted of questions about the demographic background of students, their gender, ethnicity, religion, gender/religion/ethnicity-based behaviour expectations, parents' discussion about these, their importance in students' lives and decision making, as well as the conceptualised elements of science identity along with voluntary and obligatory identity. Overall, the survey elicited students' standpoints on these factors, thoughts about their values, and preferences related to science identity.

Because the nature of survey design is to answer a variety of questions based on a nominal, ordinal, or scale type variables, the analysis method is by no means a straightforward procedure. For essential questions, such as gender, religion, and ethnicity, descriptive statistics were employed. For further understanding, the chi-square test was used to determine whether there was a significant association between the two nominal variables. In addition, due to the lack of a formula to obtain values about students' science identity, related questions about science identity were analysed using factor analysis; consequently, a new set of data was created about the students' level of science identity. The findings chapter presents all the details of the analysis, which was conducted using SPSS 29.0. However, methods such as frequency analysis, chi-square, or factor matrix used in this research are discussed further in this chapter.

3.8.3 Phase 3. Collecting Qualitative Data from Year 10 Students Through Interviews

During phase 3, five student interviews, one male and four females, were conducted. Initially, 8 students, four female and four males, volunteered to take part in the research. However, three male students changed their minds. Because of the ethical considerations mentioned on the information sheets and consent forms, all participants had the right to withdraw their consent at any point in the research without any explanation for doing so. Therefore, the students' reasons for withdrawal were not questioned or shared with me. Despite this, a science teacher reassured me that there were no concerns related to my research or me as the researcher; those students simply decided to not participate because a conflict of responsibilities.

All students who were interviewed also took part in the quantitative phase; however, because identifying information was not asked for in the survey, it was not possible to match the survey data and interview. To ensure privacy protection, the names of students were anonymised similar to the teachers. Some information about the students is given below.

Table 6 Overview of students' gender, ethnicity, religion, and science course enrolment

Student's name	Gender	Religion	Ethnicity	Science Course Enrolment
Amina	Female	Muslim	Asian	Triple science
Natalia	Female	Christian	White	Triple science
Priya	Female	Hinduism	Asian	Triple science
Andreea	Female	Christian	White	Triple science

Arjun	Male	Hinduism	Asian	Combined science

The data collection tool used in Phase 3 was also tested during the pilot study as explained previously. Also, the data collected from teachers and from the survey with students were also valuable in improving the student interviews and the questions to be asked. During the interview, detailed experiences and thoughts about how students' gender, religion, and ethnicity impacted their science identity were elicited for detailed understanding, issues which may not have been explored by teacher interviews or surveys. All student interviews were conducted on the school premises when a member of the school or a science teacher was present. The third person present did not interfere with the interviews, concurrently attention was given to ensuring students felt comfortable to talk freely. The interviews were analysed using thematic analysis. Further details on thematic analysis are provided later in this thesis, and detailed results can be found in the findings chapter.

3.9 Qualitative Data Analysis Method: Thematic Analysis

To analyse the qualitative data gathered in the research, the thematic analysis method was employed. Thematic analysis is a widely used method for analysing data and reporting focused patterns within a dataset in social sciences and psychology (Braun and Clarke, 2013). It focuses on comprehensive, context-specific, and subjective data and understanding (Cohen *et al.*, 2018). Whilst it does not have specific guidelines for data collection methods, theoretical perspectives, or any research framework, it has an advantage in terms of flexibility (Braun and Clarke, 2013). There are several software programmes, such as Computer Assisted Qualitative Data Analysis Software (CAQDAS) or NVivo, that can be useful for thematic analysis (Cohen *et al.*, 2018). NVivo, the software used in this research, organises and stores different types of data, such as audio files, pictures, memos, images, and graphics; it also enables users to store data by queries, codes, nodes, and reports within different files (Cohen *et al.*, 2018; Braun and Clarke, 2013).

Thematic analysis with a semantic coding focus was employed in this research. To provide clarity regarding semantic coding, this basically summarises the explicit contents of the data; in other words, semantic codes reflect what participants say and are based on their language and concepts (Braun and Clarke, 2013). The process of thematic analysis coding started with reading the whole interviews in detail to identify important matters that could answer the research questions or highlight crucial circumstances. To ensure points relevant to the research questions were not missed, a broad but specific coding approach was adopted; however, any unnecessary data, which lacked relevance to the research questions, was not coded. Further details of the data analysis are provided in the findings chapter.

3.10 Quantitative Data Analysis Methods: Descriptive Statistics, Chi-Square Tests and Factor Analysis

Descriptive statistics, chi-square test, and factor analysis were important elements of the data analysis. When all the data collection was completed, the dataset provided a comprehensive picture that focused on meaningful insights and contributed to all research datasets and the topic. Before going through the analysis methods adopted in this research, I, as a researcher, first needed to clarify the data type (scales of data) collected in this research. The survey applied in this research consisted of only two types of data, nominal and ordinal.

A nominal scale specifies categories, such as men and females. An ordinal scale classifies and orders data. For instance, these scales may have 'strongly agree' as stronger than 'agree' or substantially stronger than 'very little'. An interval scale adds a metric – a regular, equal interval between data points – whilst retaining categorisation and order. The difference between 3 and 4 degrees Celsius is the same as 98 and 99 degrees Celsius. A ratio scale combines categorisation, order, and an equal-interval metric with a strong fourth feature: a genuine zero. Thus, the researcher can quickly calculate proportions such as 'twice as many as', 'half as many as', 'three times the quantity of', and so on (Cohen *et al.*, 2018; Dancey and Reidy, 2007)

The categorisation of data is important because many factors depend on the type of data. For example, the selection of an appropriate statistical test depends on the measurement scale used. It is not correct and suitable to use statistical tests designed for interval or ratio data on nominal or ordinal data; for instance, it is not appropriate to use averages (means) when dealing with nominal data, nor should t-tests and

‘Analysis of Variance’ be employed to analyse ordinal data (Cohen *et al.*, 2018, p. 727).

Descriptive statistics do what they say, they describe, so that the gathered data can then be analysed and interpreted. Descriptive statistics include frequencies, measures of dispersal (standard deviation), measures of central tendency (means, modes, medians), standard deviations, crosstabulations, and standardised scores (Cohen *et al.*, 2018; Dancey and Reidy, 2007). One of the most common types of descriptive statistics is the measurement of central tendency (Dancey and Reidy, 2007). However, any measurement of central tendency (mean, median, and mode) was not used in the analysis of questions; the descriptive statistics part consists solely of frequency analysis, including percentages. The reason for not adopting any measurement of central tendency is that they would not answer any research questions, whereas a frequency analysis of some questions could provide overall information about the population related to the concerned research topic.

Another way to analyse questions is to identify any association between variables. A correlational analysis is used for exploring any relationship between variables; also, a chi-square test offers another way to analyse data to determine whether there is any significant association between variables (Dancey and Reidy, 2007; Turhan, 2020). A correlational analysis, such as Pearson’s correlation for continuous variables or Spearman’s rank correlation for ordinal variables, is not appropriate to use with nominal and ordinal data. Therefore, in my research, the chi-square test was used because of the method and appropriateness given the variable type.

The major goal of this research was to understand how gender, religion, and ethnicity impacts students’ science identities. Therefore, questions were asked about their identities and their relationships (one identity could be stronger/obligatory than the other, or vice versa, or identities could be changeable from time to time and place to place). In this research, I was not able to investigate each identity reflection of students in different contexts, but with a questionnaire, data about students’ general thoughts and attitudes towards their values and identities were collected. Therefore, if there was any association between variables, understanding how certain variables are related to each other through a chi-square analysis of some questions served the purpose of this research. For example, when examining the impacts of gender on students’ science career plans, the analysis of questionnaire data may have revealed no significant association between gender and science career plans. In this case, it would still be possible to find out whether any student or teacher who participates in an interview believes that her or his gender impacts students' science career plans, and how those impacts are realised. However, if the quantitative data analysis had revealed no significant association and none of the participating students and teachers in the interviews mentioned these impacts, this assumption would be discarded. Therefore, both types of collected data were beneficial in establishing general tendencies related to assumptions and eliciting more details related to them.

The analysis of variables using chi-square was interpreted using a p-value. The p-value, also named alpha (α), measures the probability of obtaining the observed results of a statistical test; and ranges from 0 to 1 (Turhan, 2020). The interpretation of the p-value is based on a predetermined level of significance, which is typically set at 0.05. Additionally, as seen in many publications, results are given as statistically significant or non-significant (Dancey and Reidy, 2007). To clarify, if the p-value is less than or equal to 0.05, the null hypothesis is rejected, and the result is considered statistically significant (Turhan, 2020). The null hypothesis is a statement that there is no significant difference between two variables. Therefore, if the p-value is greater than 0.05, the null hypothesis is not rejected, and the result is not statistically significant. The concept of statistical significance represents whether an outcome, such as a difference or association, could happen by chance (Cohen *et al.*, 2018).

In quantitative part of this research, factor analysis was used to generate a new dataset representing science identity. Factor analysis is a statistical method that reduces data complexity by summarising the relationships between questions that measure related constructs. While each question provides valuable data, factor analysis condenses several related questions into a new and meaningful variable, which is representation of the broader concept being studied (Dancey and Reidy, 2007).

In this study, the broader concept is science identity. As explained in the literature review chapter, the conceptualisation of science identity includes identification and recognition as science person, interest in science, competence in science, and having science-related science career plan. Each conceptualised element of science identity was measured with multiple questions in the questionnaire. Therefore, by conducting factor analysis, a summary score for each component of science identity was generated.

For example, in the identification and recognition component, four questions were used to measure students' self-identification as a science person and recognition as a science person by people – family, friends, and teachers. Factor analysis helped to determine the strength of the association between each question and the underlying factor of science identity. For instance, the factor loading for family recognition as a science person was 0.947, representing a stronger contribution of this element in this construct compared to others.

In summary, factor analysis allowed me to summarise the responses of multiple questions and generate new variables for constructs of science identity. These new variables of science identity elements were then used in subsequent analysis. Ultimately, the final variable of science identity was used to explore how students' science identity is influenced by students' gender, religion and ethnicity. The detailed analysis of each component, including factor loadings and their contributions to the science identity construct, is provided in the finding chapter.

In the next chapter, 'Findings', all data are represented within the given analysis methods. However, before moving on to the next chapter, the ethical considerations that were followed and paid attention to in this research are explained.

3.11 Ethical Considerations

I, as the researcher of this study, read numerous resources so that I could conduct this research in an ethical manner. Because the research focused on science identity involving participants under the age of 18, I received ethical approval in advance, prior to contacting schools and piloting research data collection instruments. Brunel University, London has strict ethical procedures for conducting ethical research with teachers and students.

For the ethical approval application, the draft version of data collection instruments, the draft email to send to schools, information sheets for school offices, headteachers, science teachers, students, and parents/guardians, and consent forms for teachers, students, and parents/guardians of students were submitted to and approved by the ethics committee. Moreover, I obtained a Disclosure and Barring Service (DBS) check, which is mandatory, in order to enable me to study with individuals who are younger than 18.

Invitation emails were sent to all schools, teachers, or school offices via individualised emails to ensure no mass invitations were dispatched. All email addresses were sourced from school websites, which are publicly available. To protect privacy and anonymity, the procedures mentioned earlier were followed, and all interactions with respondents were conducted on an individual basis. Before beginning the research, I informed parents/guardians about the research and offered the students and their parents/guardians the opportunity to refuse to participate. Before each individual participated, the necessary consent was obtained. Throughout the research, students and their parents/guardians were able to withdraw their consent at any time.

All data collection procedures took place on the school premises. During student interviews, as an additional ethical consideration, there was a school staff member or a teacher present. To maintain the confidentiality and privacy of all participants, students, teachers, and the school, every effort was made to ensure anonymity in all research reports. The data collected will be kept strictly confidential, available only to my supervisor and myself, and not used for other purposes which were specified without the further consent of all those involved being obtained.

The necessary ethical considerations were followed during the research process. Because of the nature of the research topic and its focus on how students' gender, religion and ethnicity impact their science identity through the lens of intersectionality, there was the potential for sensitive topics to arise which would cause participants some tension or discomfort. Such topics include identification with a gender not approved by people around them, having a minority ethnic background, or certain religious beliefs, and certain topics conflicting with their religion such as evolution or sex education. As the researcher, I therefore paid attention to the sensitivity of the research components.

To alleviate any concerns, each participant received information sheets that explained the ethical considerations and precautions taken before deciding to participate, and they were asked to confirm they had read the information sheet on the consent form. In addition, participants were assured that none of the individual information or data they provided would be disclosed. They were also informed that they had the right to end their participation at any time. Furthermore, each interview was conducted in a manner that respected participants' personal beliefs, values, experiences, thoughts, and information. Questions were asked in a respectful way, providing participants with time to think or pass and move on to the next question. The approach that was adopted was based on being open and respectful. Participants were told that their views were valued and that there would be no pressure or judgements made about what they shared.

The research is sponsored by the Turkish Government, Turkish Education Consultancy, London. The sponsor of the research funds the research without any requirement other than informing them that my PhD research was successfully completed. Whilst conducting my research, any data that I collected would not be shared with my sponsor or any organisation within the Turkish Government. My research will only be accessible by the sponsor and everyone else following the successful completion of my thesis and any publishing of works related to my research.

3.12 Ethical Reflexivity and Researcher Positionality

To be able to conduct the research, it is important to state my positionality and how my background, beliefs, and experiences could influence the research process. As mentioned in the introduction chapter, the motivation to conduct this research is that, as a researcher, my personal identities have been shaped and changed by my beliefs, norms, and values. As a result, my approach to everything, especially the research in this context, has been influenced in regard to the questions I asked, how I interact with students and teachers, what gets my attention, and how I interpret the data. These intersecting elements and my identities positioned me in both insider and outsider roles as a researcher.

The background and values I have, such as being Turkish, being female, being Muslim, and having a science identity, have provided me with a particular perspective on the intersection of these. Within these intersections and familiar context as a researcher who personally experienced influences of gender, religion, and ethnicity on science identity, being an insider in this research allowed me to bring in and cultivate empathy and gain a deeper understanding. This helped in gathering rich data to enhance research outcomes. Additionally, there were potential challenges that required me to be mindful and open, even in familiar situations. Therefore, I carefully designed semi-structured, non-leading, and thoughtfully worded questions in all data collection tools to ensure inclusivity and respect for participants' diverse experiences and values.

On the other hand, my positionality was not always that of an insider because I am not part of the groups they belong to, nor a believer in what they believe, nor do I hold the same values, nor do I share their perspectives and understandings. Therefore, being an outsider as the researcher of the study helped me to be aware of a variety of perspectives to be able to interpret and analyse the data. I recognised that my lack of common ground could limit my ability to understand the full complexity and nuances; therefore, I remained conscious of the need to understand various diverse viewpoints, especially about beliefs and practices I do not know, hold, or have direct experience with.

In addition to all these, as an insider and outsider, I experienced differences because, while meeting participating science teachers, I introduced myself and told them I worked as a science tutor in Türkiye. So, while conducting research, I felt that I was an insider because I had science teaching experience, and the participating teachers accepted me as a visiting colleague. At the same time, I was an outsider because I was the researcher. This was similar during the data collection from the students because, as a visiting researcher, I noticed they were hesitant. However, I was a PhD student, so the participating students and I had a common point.

Throughout the research, I took several steps to ensure that my positionality, including potential biases, did not influence the research process. The mentioned steps involved the early stage of deciding the main research questions, designing data collection tools, as well as specific ethical practices such as obtaining participants' consent and their guardians'/parents' consent, ensuring confidentiality, and regularly paying attention to my biases, beliefs, or experiences to keep my distance and not be influenced by them. In addition to these, I always sought feedback from my supervisors and discussed circumstances with experienced academics and colleagues to ensure that the perspective I adopted was balanced and not influenced.

Ultimately, I would like to acknowledge that my positionality is not something I should overcome; my positionality was a source of strength and motivation for this research. Being open and transparent regarding my positionality, I was able to conduct research that is both valuable and informative, as well as shedding light on the complex interplay between gender, religion, and ethnicity with science identity.

4 Findings

4.1 Quantitative Data Collection from Students

4.1.1 Analysis of the First Part of the Questionnaire: Gender, Ethnicity, and Religion Related Questions

To investigate students' science identity and how it is influenced by their gender, religion, and ethnicity, 145 Year 10 students filled out the questionnaire. There were some questions that were left blank, and some questions that were checked with cross-check questions to ascertain whether the participating students had made up the answer, especially for the Likert-scale type of questions. To analyse the data, a frequency analysis and chi-square analysis were used. In terms of the chi-square analysis, only the significant associations are presented in this chapter under the related topics; if the associations are not significant, these results will be given in the appendix.

4.1.1.1 Analysis of gender-related questions

In this research, four answer options were provided for participants to indicate their gender: male, female, non-binary, and rather not say. Overall, 64 of the participants were male, 70 were female, 3 were non-binary, 5 chose the 'rather not say' answer, and 3 did not answer this question.

Frequency analysis of gender-related questions:

Table 7 Frequency analysis of responses to gender-based behavioral expectations

Expected to behave in a specific way based on your gender		Frequency	Percent
Valid	Yes	104	71.7
	No	39	26.9
	Total	143	98.6
Missing		2	1.4

Total		145	100.0

Among 145 students, 104 (71.7% of the total) stated that they are expected to behave in a way that is appropriate for their gender. Conversely, 39 (26.9% of total) students stated that they did not think gender will affect their behaviour. Two students left the question blank, resulting in missing data.

Table 8 Frequency analysis of responses to Parents' talk about gender and career plan

Parents' discussion about the impact of gender on your future career plans		Frequency	Percent
Valid	Yes	44	30.3
	No	98	67.6
	Total	142	97.9
Missing		3	2.1
Total		145	100.0

In total, 44 (30.3% of the total) students reported they discuss gender's impact on career plans with their parents, whilst 98 (67.6% of the total) students and their parents did not. There were a total of 3 (2.1%) missing values for this question.

Table 9 Frequency analysis of responses to gender impacts on career plans

Gender impacts on career choices		Frequency	Percent
Valid	Not sure	19	13.1
	No influence at all	29	20.0

	Little influence	28	19.3
	Some influence	45	31.0
	Great influence	19	13.1
	Total	140	96.6
Missing		5	3.4
Total		145	100.0

The majority (45 students) stated that gender has some influence, while 19 believed it has a great influence. Conversely, 28 students said gender has ‘little influence’ compared to those who stated there is no influence of gender on their career plan. There were a total of 5 missing values, accounting for 3.4% of the total.

Chi-square analysis of gender related questions:

To explore associations between the responses related to gender questions, chi-square was used to analyse the data. The following analyses revealed statistically significant associations ($p < .05$):

Table 10 Chi-square analysis of Expected Gender Behaviour * Gender Importance in Decision Making Regarding Career

		Gender importance in decision making regarding career					
		Not sure	No influence at all	Little influence	Some influence	Great influence	Total
Expected gender behaviours	Yes	8	18	22	36	17	101
	No	11	11	6	9	2	39
Total		19	29	28	45	19	140

Chi-square value	14.79
Degrees of Freedom	4
p-value	0.005
The chi-squared test revealed a statistically significant association (p < .05) between expected gender behaviour and the importance of gender in decision-making about students' careers; therefore, the null hypothesis must be rejected.	

However, this did not provide information about the nature or strength of this relationship.

Table 11 Chi-square analysis of parents' talk about gender career * Gender importance in decision making regarding career

		Gender importance in decision making regarding career					
		Not sure	No influence at all	Little influence	Some influence	Great influence	Total
Parents' talks about gender and career	Yes	2	2	9	18	12	43
	No	17	27	19	27	6	96
Total		19	29	28	45	18	139

Chi-square value	24.05
Degrees of Freedom	4
p-value	<0.001
The chi-squared results indicate a statistically significant association ($p < 0.05$) between the variables; therefore, the null hypothesis must be rejected. However, they do not provide information about the nature or strength of this relationship.	

The chi-square tests of responses to the following questions are not statistically significant; therefore, these can be found in the appendix:

- Gender and Expected gender behaviour
- Gender and Parents' talk about gender and career
- Gender and Gender importance in decision making regarding career
- Expected gender behaviour and Parents' talk about gender career

4.1.1.2. Analysis of ethnicity related questions

Frequency analysis of ethnicity related questions:

The table presents the data about the participating students' ethnicity. The highest number of students, 52 (35.9% of total), chose the category of "Asian/Asian British", whereas the second-largest ethnic group was "White", with a total of 37 (25.5% of total) students. Replies were missing from 7 students, representing 4.8% of the total.

Table 12 Frequency analysis of responses to ethnicity

Ethnicity of participating students		Frequency	Percent
Valid	White	37	25.5
	Mixed/Multiple ethnic groups	12	8.3
	Asian/Asian British,	52	35.9

	Black/African/Caribbean/Black British	18	12.4
	Chinese	3	2.1
	Arab	14	9.7
	Other ethnic group	2	1.4
	Total	138	95.2
Missing		7	4.8
Total		145	100.0

The following table presents frequency data regarding the importance of ethnicity for students. As shown, more than 70% of participants considered ethnicity "Important" (57 students) or "Extremely Important" (47 students) indicating its significance for most students. However, a smaller number of students find ethnicity "Not important" (11 students, 7.6% of the total), while 3 students did not answer this question, although the reason for this was not certain.

Table 13 Frequency analysis of responses to importance of students' ethnicity

Importance of Ethnicity for Students		Frequency	Percent
Valid	Not important	11	7.6
	Not very important	9	6.2
	Moderately important	18	12.4
	Important	57	39.3
	Extremely important	47	32.4
	Total	142	97.9

Missing		3	2.1
Total		145	100.0

Overall, 122 students, 84.1% of the total, stated that their parents talked about their ethnicity with them. Only 19 (13.1%) students reported their parents do not talk about their ethnicity.

Table 14 Frequency analysis of responses to parents' talk about ethnicity

Parents' Talk about Ethnicity		Frequency	Percent
Valid	Yes	122	84.1
	No	19	13.1
	Total	141	97.2
Missing		4	2.8
Total		145	100.0

The following table reveals that 35 students, 24.1% of participants, said their parents talked to them about ethnicity and career plans, whilst the majority (97, 66.9% of the total) say their parents do not.

Table 15 Frequency analysis of responses to parents' talk about ethnicity and career plans

Parents' talk about ethnicity and career		Frequency	Percent
Valid	Yes	35	24.1
	No	97	66.9

Total	132	91.0
Missing	13	9.0
Total	145	100.0

The table presenting data on the impact of ethnicity on their job choices shows that 45 students, or 31.0% of the population, thought their ethnicity has “little influence” on their career plans. In addition, 36 students (24.8% of the total), which is the second-biggest group, chose "No influence at all” whereas 12 students (8.3%) thought there was “Great influence” of their ethnicity on their career plan. Among the students who participated in this part of the research, seven students did not answer this question.

Table 16 Frequency analysis of responses to impacts of ethnicity on decision making about career

Ethnicity impact on decision making about career		Frequency	Percent
Valid	Not sure	16	11.0
	No influence at all	36	24.8
	Little influence	45	31.0
	Some influence	29	20.0
	Great influence	12	8.3
	Total	138	95.2
Missing		7	4.8
Total		145	100.0

Chi-square analysis of ethnicity related questions:

A chi-square test performed to explore the association between the importance of ethnicity for students and parents' talk about ethnicity yielded the following results.

Table 17 Chi-square analysis of importance of ethnicity for students * parents' talk about ethnicity

		Parents' talk about ethnicity		
		Yes	No	Total
Importance of ethnicity	Not important	3	8	11
	Not very important	9	0	9
	Moderately important	13	5	18
	Important	53	3	56
	Extremely important	44	3	47
Total		122	19	141

Chi-square value	42.87
Degrees of Freedom	4
p-value	<0.001
The chi-square results revealed a statistically significant association (p < .05) between the two variables; therefore, the null hypothesis must be rejected. However, they do not provide information about the nature or strength of this relationship.	

A chi-square test performed to explore the association between parents' talk about ethnicity and career, and the importance of ethnicity in decision making about careers, yielded the following results.

Table 18 Chi-square analysis of parents' talk about ethnicity and career * ethnicity importance on decision making about career

		Ethnicity importance on decision making about career					
		Not sure	No influence at all	Little influence	Some influence	Great influence	Total
Parents' talk about ethnicity and career	Yes	4	2	8	10	9	33
	No	11	31	32	18	3	95
Total		15	33	40	28	12	128

Chi-square value	24.04
Degrees of Freedom	4
p-value	<0.001
The chi-squared results revealed a statistically significant association ($p < .05$) between the two variables; therefore, the null hypothesis must be rejected. However, they do not provide information about the nature or strength of this relationship.	

The chi-square tests of responses to the following questions are not statistically significant; therefore, these can be found in the appendix:

- Ethnicity * Importance of ethnicity
- Ethnicity * Parents' talk about ethnicity
- Ethnicity * Parents' talk ethnicity and career
- Ethnicity * Ethnicity importance on decision making about career
- Importance of ethnicity for students* Parents' talk about ethnicity and career
- Importance of ethnicity for students * Ethnicity importance on decision making about career
- Parents' talk about ethnicity * Parents' talk about ethnicity and career
- Parents' talk about ethnicity * Ethnicity importance on decision making about career

4.1.1.3. Analysis of religion related questions

The frequency analysis regarding the religion of students is presented below. Like ethnicity, religious beliefs or non-beliefs of students also vary. The majority of the students believe in Islam, and the second most commonly followed religion is Christianity.

Frequency analysis of religion related questions:

As indicated in the table below, the religious beliefs of the participants are diverse. The predominant religion among participants is Islam as 57 (39.3%) of students are Muslim. Among the remainder, 40 (27.6%) are Christians, of and 22 (15.2%) are Hindus in this group. Additionally, 9 (6.2%) students did not answer this question.

Table 19 Frequency analysis of students' responses to their religion

Religion		Frequency	Percent
Valid	No religion	10	6.9
	Buddhist	2	1.4
	Christian	40	27.6
	Hindu	22	15.2
	Jewish	1	.7
	Muslim	57	39.3
	Sikh	1	.7
	Other	3	2.1
	Total	136	93.8
Missing		9	6.2
Total		145	100.0

Table 20 presents the data on how important religion is for students who participated in the research. It reveals that 62.1% of students find religion to be "Extremely important" and "Important". Only 10 (6.9%) students stated that they find religion "Not important. The number of missing data points, 15 (10.3%), is slightly higher than the previously answered question.

Table 20 Frequency analysis of students' responses to importance of religion

Importance of religion for students		Frequency	Percent
Valid	Not important	10	6.9
	Not very important	11	7.6
	Moderately important	19	13.1
	Important	33	22.8
	Extremely important	57	39.3
	Total	130	89.7
Missing		15	10.3
Total		145	100.0

The following table presents data on whether students' parents talk about their religion. The majority, 113 (77.9%) students, said that their parents talk about their religion. However, 18 (12.4%) stated that their parents do not. Overall, 14 (9.7) students did not answer this question.

Table 21 Frequency analysis of students' responses to parents' talk about religion

Parents' talk about religion		Frequency	Percent
Valid	Yes	113	77.9
	No	18	12.4
	Total	131	90.3

Missing	14	9.7
Total	145	100.0

Table 22 represents the information provided by students about how important their religion is when making career decisions. Although 22 (15.2%) students thought their religion has a “Great influence” on this, 38 (26.2%) students said that their religion is important when deciding what they will do in the future. Overall, 24 (16.6) students chose “No influence at all”.

Table 22 Frequency analysis of responses to importance of religion in decision making about career

Religion’s importance in decision making about career		Frequency	Percent
Valid	Not sure	13	9.0
	No influence at all	24	16.6
	Little influence	25	17.2
	Some influence	38	26.2
	Great influence	22	15.2
	Total	122	84.1
Missing		23	15.9
Total		145	100.0

Chi-square analysis of religion related questions:

In this part, all chi-square test results are presented in this section; none are in the appendix. The reason for this is that for religion-related questions, only one question did not reveal a significant association; therefore, it is important to highlight that in this section. Regarding religion and religion related questions, chi-square tests were performed to test the relationships between the questions below:

- Students’ religion
- Importance of religion for students
- Parents’ talk about religion
- Religion importance in decision making about career

Chi-square tests were conducted to explore associations between religion-related variables. The following analyses revealed statistically significant associations ($p < .05$):

Table 23 Chi-square analysis of students' religions * importance of religion for students

		Importance of religion for students					
		Not important	Not very important	Moderately important	Important	Extremely important	Total
Students' religion	No religion	2	0	0	0	0	2
	Buddhist	0	1	1	0	0	2
	Christian	1	7	7	10	15	40
	Hindu	3	2	5	7	5	22
	Jewish	1	0	0	0	0	1
	Muslim	1	1	4	16	35	57
	Sikh	0	0	0	0	1	1
	Other	0	0	1	0	1	2

Total	8	11	18	33	57	127

Chi-square value	77.47
Degrees of Freedom	28
p-value	<0.001
The chi-square results revealed a statistically significant association ($p < .05$) between the two variables; therefore, the null hypothesis must be rejected. However, they do not provide information about the nature or strength of this relationship.	

A chi-square test to explore the association between students' religions and parents' talk about religion yielded the following results.

Table 24 Chi-square analysis of students' religions * parents' talk about religion

		Parents' talk about religion		
		Yes	No	Total
Students' religions	No religion	2	1	3
	Buddhist	1	1	2
	Christian	31	9	40
	Hindu	20	2	22
	Jewish	0	1	1
	Muslim	55	2	57
	Sikh	1	0	1
	Other	2	0	2
Total		112	16	128

Chi-square value	19.29
Degrees of Freedom	7
p-value	0.007
The chi-squared results revealed a statistically significant association ($p < .05$) between the two variables; therefore, the null hypothesis must be rejected. However, the results do not provide information about the nature or strength of this relationship.	

A chi-square test performed to explore the association between students' religions and religion importance in decision making about career yielded the following results.

Table 25 Chi-square analysis of students' religion * religion importance in decision making about career

		Religion importance in decision making about career					
		Not sure	No influence at all	Little influence	Some influence	Great influence	Total
Students' religions	No religion	1	1	0	0	1	3
	Buddhist	0	1	0	0	0	1
	Christian	6	10	7	11	1	35
	Hindu	2	8	6	4	1	21
	Jewish	0	0	0	1	0	1
	Muslim	3	3	12	21	16	55
	Sikh	0	0	0	1	0	1
	Other	0	1	0	0	1	2

Total	12	24	25	38	20	119

Chi-square value	19.29
Degrees of Freedom	7
p-value	0.042
The chi-square results revealed a statistically significant association (p < .05) between the two variables; therefore, the null hypothesis must be rejected. However, the results do not provide information about the nature or strength of this relationship.	

A chi-square test conducted to explore the association between the importance of religion for students and parents' talk about religion yielded the following results.

Table 26 Chi-square analysis of importance of religion for students * parents' talk about religion

		Parents' talk about religion		
		Yes	No	Total
Importance of religion for students	Not important	5	5	10
	Not very important	7	4	11
	Moderately important	15	4	19
	Important	30	3	33
	Extremely important	55	2	57
Total		112	18	130

Chi-square value	22.19
Degrees of Freedom	4
p-value	<0.001
The chi-squared results revealed a statistically significant association (p < .05) between the two variables; therefore, the null hypothesis must be rejected. However, the results do not provide information about the nature or strength of this relationship.	

A chi-square test performed to explore the association between the importance of religion for students and religion importance in decision making about career yielded the following results.

Table 27 Chi-square analysis of importance of religion for students * religion importance in decision making about career

		Religion importance in decision making about career					
		Not sure	No influence at all	Little influence	Some influence	Great influence	Total
Importance of religion for students	Not important	4	3	0	2	1	10
	Not very important	0	8	0	1	0	9
	Moderately important	2	6	8	1	1	18
	Important	5	3	11	7	2	28
	Extremely important	2	4	6	27	17	56

Total	13	24	25	38	21	121

Chi-square value	22.98
Degrees of Freedom	16
p-value	<0.001
The chi-square results revealed a statistically significant association (p < .05) between the two variables; therefore, the null hypothesis must be rejected. However, they do not provide information about the nature or strength of this relationship.	

A chi-square test conducted to explore the association between parents' talk about religion and religion's importance in decision making about careers yielded the following results.

Table 28 Chi-square analysis of parents' talk about religion * religion importance in decision making about career

		Religion importance in decision making about career					
		Not sure	No influence at all	Little influence	Some influence	Great influence	Total
Parents' talk about religion	Yes	10	19	23	37	21	110
	No	3	5	2	1	1	12
Total		13	24	25	38	22	122

Chi-square value	8.85
Degrees of Freedom	4

p-value	0.065
The chi-square results revealed no significant association (p > .05) between the two variables.	

The first part of the survey focused on demographic information such as gender, ethnicity and religion, and included questions about how these influenced students ' decision making and whether these are important to students. The findings from the first part were mostly in the form of descriptive statistics, drawing a picture of participants' values and backgrounds which are the elements in this research. The first part serves as the foundation of the research questions designed to explore the science identity of students.

4.1.2. Analysis of the Second Part of the Questionnaire: Science Interest, Self-Identification and Recognition as a Science Person, Career Plan in Science, and Science Competence of Students

All questions in the second part of the questionnaire, which are elements of the conceptualised science identity, were analysed in depth to provide rich information. Thus, descriptive statistics — including frequencies and percentages — for these questions are presented under four main themes. In addition, a factor analysis of questions under these four themes was performed to generate a summary of the results. In this section, cross-check questions were also used to check whether answers were coherent with the exact questions, but these were not analysed.

4.1.2.1 Science interest questions

This part of the findings shows how students feel and what they do when they are interested in and involved with science. The following points were measured for science interest:

<u>Interest in science</u>

This part presents frequency data about whether students are interested in science. Overall, 24 (16.6%) students totally agreed, whilst 35 (24.1%) students agreed they were interested in science. However, 50 students (34.5% of the sample) chose "Disagree" or "Totally disagree" to their science interest.

Seeking more information

The data are about whether students have more interest in learning additional science or being part of science activities. Only 9 (6.2%) students said, “Totally agree”, and 25 (17.2%) students chose “Agree”. Notably, 69 (47.6%) students chose either "Totally disagree" or "Disagree" when asked if they wanted more information after a science exercise.

Understanding the world

The data displays what students think about the statement, “Knowing science helps me understand how the world works". Overall, 11 (7.6%) students chose “Totally agree” and “Agree”, and 7 (4.8%) responded “Not Sure”. By contrast, most students, 88 (60.7%), said they totally disagree with the statement, and 33 (22.8%) students said they disagree.

Reading science-related books

This data reveals that whether students enjoy reading science-related books. 66 (45.5%) students and 29 (20.0%) students said they "Totally disagree" or "Disagree", respectively, whilst a minority of students 4 (2.8%) “Totally agree” and 16 (11.0%) students “Agree”.

Watching science-related videos/films/TV shows

The data is about whether students like watching science-related TV shows or videos. In total, 61 (42.1%) students responded, ‘Totally disagree’, or ‘Disagree’. 14 (9.7%) students said they ‘totally agree’ and 30 (20.7%) students ‘Agree’ that they like watching TV shows or videos related to science.

Overall, the findings showed that the students exhibited a range of feelings about science, different levels of excitement after activities, and different tastes for different types of science-related material. This shows that the students were engaged in a variety of ways with science.

Factor analysis of questions about science interest

A factor analysis was conducted and generated factor loadings, which indicate the degree to which each question contributes to the broader concept – science interest.

The table below shows the factor loadings for each question under the concept of interest in science.

Table 29 Factor analysis of questions related to science interest

Questions	Factor loadings
I am interested in science (Q21)	.648
After an interesting science activity is over, I look for more information about it (Q22)	.750
Knowing science helps me understand how the world works (Q24)	.557
I like reading books which are related to science (Q25)	.855
I like watching videos and/or TV shows which are related to science (Q26)	.765

Extraction Method: Unweighted Least Squares.

a. 1 factor extracted. 5 iterations required.

Table 29 indicates the factor loadings, which show how strongly each question contributes to broader factor – science interest.

4.1.2.2. Identification and recognition as a science person

An analysis was performed of data about whether students identify as a science person and what people around them think about their being science people. There are four statements representing the thoughts of students.

Self-identification as a science person

In the first table, in terms of identification as a science person, 13 (9.0%) students totally agreed and 24 (16.6%) students agreed that they self-identified as a science person. In contrast, 70 (48.3%) students expressed either "Total Disagreement" or "Disagreement" with the self-identification as a science person.

Family recognition as a science person

This question reveals that 12 (8.3%) students and 15 (10.3%) students chose the options of “Totally agree” and “Agree”. Again, the majority of students, 70 (48.3%) in total, indicated that their family expressed either "Total disagreement" or "Disagreement" with the idea that they think the student is a science person.

Friends’ recognition as a science person

74 (51.0%) and 57 (39.3%) students expressed that they strongly disagreed or disagreed with the questions, whilst 26 (7.9%) students totally agreed that their friends see them as a science person, and 15 (10.3%) students stated that they “Agree” with the statement.

Teachers’ recognition as a science person

10.3% of students agreed or totally agreed that their teachers saw them as a science person, while 39.3% disagreed or totally disagreed.

In summary, these findings indicate a gap between how students see themselves and how others recognise them as a science person. The reason for this discrepancy could be a lack of communication, showing their science person characteristics to people around them, or a lack of being noticed. This part was also focused on in the interviews with students.

Factor analysis of questions about identification and recognition as science person

By conducting a factor analysis, factor loadings of questions related to identification and recognition as a science person were generated. These indicate the degree to which each question contributes to the broader concept of identification and recognition as a science person. The table below shows the factor loadings for each question related to this component.

Table 30 Factor analysis of questions related to identification and recognition as science person

Questions	Factor loadings
I think I am a science kind of person (Q29)	.879
My family thinks of me as a science person (Q30)	.947
My friends think of me as a science person (Q31)	.901
My teachers think of me as a science person (Q32)	.663

Extraction Method: Principal Axis Factoring.

a. 1 factor extracted. 8 iterations required.

4.1.2.3. Career plan in science

This section provides valuable insights into students' career plans and their view of the importance of science qualifications in creating opportunities to pursue various jobs.

Science-related jobs

20 (13.8%) students and 25 (17.2%) chose "Totally agree" and "Agree" whilst 57 (39.3%) students expressed their views by choosing either "Totally disagree" or "Disagree" about their level of agreement for whether they would like to have a job in science fields.

Science qualifications

The data focus on thoughts about the adaptability of scientific qualifications. The findings reveal that a significant majority, 61.4%, expressed agreement or complete agreement with the statement.

Plan to have non-science job

This question focuses on the career plans of students, with a specific focus on not having a science career plan. This may be a reverse way of asking about their willingness to pursue a job in the science field. The findings showed that in total, 55 students, representing approximately 31% of participants, stated their total disagreement. These rates are consistent with the question about being interested in having a science-related job.

Factor analysis of questions about career plans in science

A factor analysis was conducted to generate factor loadings of questions for career plans in science. The factor loadings of questions showed how strongly each question contributes to broader concept, which is career plans in science. The factor loadings of questions are presented below:

Table 31 Factor analysis of questions related to career plan in science fields

Questions	Factor loadings
I would like to have a job that uses science (Q28)	.839
A science qualification can help you get many different types of job (Q34)	.949
I would like to have a job that does not use science (Q36)	-.694

Extraction Method: Principal Axis Factoring.

a. 1 factor extracted. 14 iterations required.

4.1.2.4 Competence in science

The tables provide valuable insights into students' subjective assessment of their competency in practical work.

Practical skills

The question presents the outcomes regarding students' self-evaluation of their practical abilities related to science. 56 (38.6%) students agreed, and 32 (22.1%) students strongly agreed with the given statement about their confidence in carrying out experiments or practical work.

Questioning skills

This part presents data on how students think about their questioning abilities. 18 (12.4%) students totally agreed that they are good at raising inquiries, whilst 31 (21.4%) students agree. Notably, 48 (34.1%) students expressed disagreement or total disagreement.

Successful science participation

The majority of students (56, 38.6%) indicated they are successful science participants by choosing "Totally agree" or "Agree".

Performance in science

With 75 (51.7%) expressing agreement or total agreement, students stated that they were confident regarding their performance in science. Overall, 32 (22.1%) students totally disagreed or disagreed with having confidence in science activities. Notwithstanding some differences, when compared with the similar question discussed previously, the discrepancy was not significant.

In general, the analysis indicates that students have different levels of confidence when it comes to their practical skills, ability to raise questions, and performance in science activities. This highlights the different experiences and self-perceptions that students may have.

Factor analysis of questions about competence in science

By conducting a factor analysis, factor loadings of questions related to competence in science were generated. These indicate the degree to which each question contributes to broader concept of identification and recognition as science person. The table below shows the factor loadings for each question related to this component.

Table 32 Factor analysis of question related to competence in science

Questions	Factor
I think I am very good at doing experiments or practical work in science lessons (Q38)	.793
I think I am very good at coming up with questions about science (Q39)	.763
I think I am a successful science participant (Q40)	.859
I think I have a good performance in science activities (Q41)	.820

Extraction Method: Principal Axis Factoring.

a. 1 factor extracted. 6 iterations required.

4.1.2.5. Science identity

The science identity variable values are generated by the elements of conceptualisation for science identity: science interest, self-identification and recognition as a science person, science career plan, and competence in science. To create a new variable for 'Science Identity', the following formula was used to calculate science identity values:

Science Identity = (0.829 * ScienceInterest) + (0.969 * Self-IdentificationRecognition) + (0.867 * ScienceCareer) + (0.585 * ScienceCompetence)

The minimum value for science identity was 6.68, and the maximum was 47.39. The range values from minimum to maximum were divided into three groups: 'no science identity', 'uncertain', and 'having a science identity'. In total, the science identities of 121 students were calculated. In terms of the main aim of this research, examining the number of students in these newly created data sets who have no science identity, are not sure, or have a science identity, is useful in portraying the distribution of the students across different characteristics such as gender, religion, and ethnicity; the three tables given below present these data. The frequency distribution of science identity according to gender reveals that a fairly low number of students have a science identity among all students, comprising 7 female students and 8 male students. The 3 students who did not disclose their gender also had a science identity. Strikingly, a high number of students (60) were placed in the uncertainty group.

Regarding the distribution of science identity across ethnicities, the diversity of students' ethnicities resulted in a lesser number for the representation of each group. As shown in the table, 5 Asian/Asian British students, 5 Black/African/Caribbean/Black British students, 4 white students, 3 Arab students, and 1 student who belonged mixed/multiple ethnic groups were identified as having a science identity. When comparing the number of students, there were more Asian students among the participants, but the number of those who identified as having a science identity was lower. Moreover, the majority of students fall into the 'uncertain' group. This could be the result of many students not being certain about questions, which meant they could not reflect their positionality or choices in questions, so they may also be part of the other two groups. Concerning holders of both religion and science identities, the tables reveal that among the students who have a science identity, Muslim students represent a slightly significant number, but 8 Christians students also have a noteworthy representation. Other students with a science identity are from the "no religion", "Hindu", and "other" groups.

In summary, these findings indicate that there is a possible connection between all these elements, and they offer useful insights into the varied situations of students who have different preferences and thoughts related to science.

Table 33 Frequency distribution of science identity by gender

		Science Identity		
		No science identity	Uncertain	Have science identity
Gender	Male	20	28	8
	Female	22	32	7

	Non-binary	1	0	0
	Rather not say	0	0	3
	Total	43	60	18

Table 34 Frequency distribution of science identity by ethnicity

		Science Identity		
		No science identity	Uncertain	Have science identity
Ethnicity	White	13	16	4
	Mixed/Multiple ethnic groups	4	6	1
	Asian/Asian British	12	25	5
	Black/African/Caribbean/Black British	4	6	5
	Chinese	1	1	0
	Arab	7	3	3
	Other ethnic group	1	1	0
	Total	42	58	18

Table 35 Frequency distribution of science identity by religion

		Science Identity		
		No science identity	Uncertain	Have science identity
Religion	No religion	4	3	1
	Buddhist	0	2	0
	Christian	16	15	5
	Hindu	10	7	2
	Jewish	1	0	0
	Muslim	12	29	8
	Sikh	0	0	0
	Other	0	1	1
	Total	43	67	17

4.1.3. Analysis of the Third Part of the Questionnaire: Obligatory and voluntary identities

Questions in this section were about the obligatory and voluntary identities of students, which, to some extent, allowed me, as a researcher, to explore students' interpretation and attribution of value to religion, gender, ethnicity, and science identities. The tables present data about the voluntary and obligatory identities of students: these identities are explained in the literature review chapter. Therefore, this part of the data provides a comprehensive understanding how students' gender, religion, and ethnicity influence their science identity. The questions about gender, religion, ethnicity, and science give students the opportunity to compare which is easier to ignore –one, both, or none. The attributed value of these allowed me to interpret students' identities.

4.1.3.1 Science and religion

In terms of science and religion, students were asked which is easier to ignore –one, both, or none – for religion and science. The tables present data concerning students' perspectives on how important their religion is and compares their science and religious identities in terms of voluntary and obligatory identity perspectives. A large number of students, 53, stated that their religion is important, and among these, 41 indicated that they would find it easier to ignore science if needed. Thus, 41 students have an obligatory religious identity in this sample. The number of students (10) who represent both science and religious obligatory identities is notable. Students who saw their religion as "not important" or "not very important" stated that they could easily ignore religion or religion and science.

Table 36 Impact of religious importance on students' perceptions of science and religion

Importance of religion for students	It is easier to ignore my religion than science	It is easier to ignore science than my religion	Both science and religion are difficult to ignore	I could easily ignore both of them
Not important	1	3	0	5
Not very important	4	1	0	5
Moderately important	3	5	4	5
Important	3	8	10	11
Extremely important	1	41	10	1

4.1.3.2. Science and gender

In terms of science and gender, students were asked which is easier to ignore: one, both, or none. The following table presents the distribution of how gender is important for students and their voluntary and obligatory science and gender identities. The number of students who saw their gender as 'important' or 'extremely important' was 60. Among the students who thought their gender is important or extremely important, 27 said that it is easier to ignore science than their gender, whilst 12 stated that they could ignore their gender easily when compared with science. These findings showed the complex links between the importance of gender and science and how easily one might disregard one identity over the other. This depends on the person and how important the identity is — whether it is an obligatory identity, or if one identity is more strongly developed as an obligatory identity.

Table 37 Impact of gender importance on students' perceptions of science and gender

Importance of Gender	It is easier to ignore my gender than science	It Is easier to ignore science than my gender	Both science and my gender are difficult to ignore	I could easily ignore both of them
Not sure	2	2	2	10
Not important at all	9	10	3	7
Moderately important	6	8	6	6
Important	7	18	6	11
Extremely important	5	9	4	0

4.1.3.3. Science and ethnicity

In terms of science and ethnicity, students were asked which is easier to ignore: one, both, or none. The following table presents the results of the analysis regarding how important ethnicity is for these students, as well as their obligatory and voluntary ethnic and science identities. For students who think their ethnic identity is not important, 22 have a voluntary ethnic identity when comparing their science attitudes; however, 12 find science easier to ignore, even though their ethnicity is not significantly important. Conversely, students who thought their ethnicity is important or extremely important (72%) find ignoring science difficult. The majority of these students, 55 in total, stated that it is difficult to ignore their ethnicity. This could be the result of developing an obligatory ethnic identity. This part of the data revealed the link between the importance of ethnicity and the ease of ignoring ethnicity, science, both, or none. As an outcome, it is important to understand how and what these students' important values are in order to invest in their science identity.

Table 38 Impact of ethnicity importance on students' perceptions of science and ethnicity

Importance of Ethnicity for students	It is easier to ignore my ethnicity than science	It is easier to ignore science than my ethnicity	Both science and my ethnicity are difficult to ignore	I could easily ignore both of them
Not important	2	3	0	5
Not very important	2	4	0	3
Moderately important	4	5	3	3
Important	6	27	9	10
Extremely important	5	28	5	7

In the final part of the survey, students were asked to compare importance of science, their gender, religion, and ethnicity when they needed to make an important decision. A frequency analysis was conducted to determine the most and least important values for students. The following table reveals that when students need to think about all four at the same time, they may prioritise one when they need to take into consideration their influences in decision-making, whilst the most important represents the obligatory identity among these four; also, the least important is another critical data interpret attitudes or attributed value to that. For example, when science is the least important and potentially science identity is not the obligatory identity, it may be influenced more by the other three. This assumption is based on the concept of obligatory and voluntary identities, when they have an obligatory identity that is not easily taken off or influenced by other identities.

Table 56 presents data concerning what students think of the importance of religion, gender, ethnicity, and science. Among the students, 69 (47.6%) considered religion to be one of the most important. In terms of the importance of ethnicity and science, when compared with others, the same number of students, 20 (13.8%) in each case stated that for them, science or ethnicity is the most important among all the given elements. The least important among these was gender, with two students viewing religion and ethnicity as being equally important. These findings showed that students have various priorities, but the majority value their religion more than other characteristics. However, data were missing from 21 students, 14.5% of the total; this could be the result of students' unwillingness to share information about their priorities, or not being sure which, for them, is the most important.

Table 39 Frequency analysis of students' views on gender, religion, ethnicity, and science for themselves as the most important

		Frequency	Percent
Valid	Religion	69	47.6
	Gender	13	9.0
	Ethnicity	20	13.8

	Science	20	13.8
	Religion=Ethnicity	2	1.4
	Total	124	85.5
Missing		21	14.5
Total		145	100.0

The following table presents the results regarding the least important elements among science, gender, religion, and ethnicity. This shows that 61 students said science is the least important, whilst 14 students (9.7%) say that they find their ethnicity the least important. A similar number of participants – 25 and 24 students, respectively – stated that they think their religion or gender is the least important. The data show that there are various opinions about the importance of these elements in students' lives. There were also 21 students who did not answer the question. This could be because of their lack of willingness to answer this specific question or their uncertainty about the matter.

Table 40 Frequency analysis of students' views on gender, religion, ethnicity, and science for themselves as the least important

		Frequency	Percent
Valid	Religion	25	17.2
	Gender	24	16.6
	Ethnicity	14	9.7
	Science	61	42.1
	Total	124	85.5

Missing	21	14.5
Total	145	100.0

In summary, in this part of the findings chapter, as well as throughout the whole chapter, a detailed analysis of various data about the gender, religion, and ethnicity of students, as well as their science identities, is represented. By cross-checking some related questions and the consistency of the given answers to these questions on the survey, the outcomes of the questionnaire were controlled, and it seems that this careful attention provided reliable findings, as seen by the frequencies and percentages presented. Also, this survey provided a large volume of information gathered from numerous students. The reason for highlighting this is that although detailed information about the reasons and methods were gathered from student interviews, the questionnaire data reveal how a diverse group of Year 10 school students in a mostly working-class environment in London experience and think about their gender, religion, and ethnicity, and their relationship to science and their science identity.

4.2 Student Interviews

The table below displays the main themes, subthemes, and codes derived from the analysis conducted in this section.

Table 41 Themes, subthemes, and codes from students' interviews

Theme 1: What students think about their being science person and what makes them a science person
Students' thoughts about science
Activities outside of school
Students' thoughts about science persons
Students' thoughts about scientists

Identification as a science person
Recognition as a science person
Interest in science
Competence in science
Career plan in science
Theme 2: Gender and science
Gender Bias in Classroom Dynamics
Perceived Gender Roles in Career Choices:
Evolution of Gender Dynamics in Science:
Impact of Gender on Interest and Competence in Science:
Theme 3: Religion and science
Relationship between Religion and Science: Religion and Career Plan
Theme 4: Ethnicity and science
Ethnicity’s Influence on Education:
Ethnicity and Science Interest:
Career Aspirations and Ethnicity Influences:
Theme 5: Intersectionality of gender, religion, ethnicity, and science identity

4.2.1. Theme 1: What Students Think about Their Being a Science Person and What Makes Them a Science Person

4.2.1.1 Students' thoughts about science

Students participating in the interviews shared a range of thoughts about science. For example, Amina stated that the lessons are challenging but also interesting, whilst Natalia emphasised the importance of science and commended her own successful skill in the subject. Students saw science as a valuable subject and find it worthy of learning.

"I actually quite enjoy them (science lessons)" (Amina)

"I feel like it is really useful … they really make my knowledge full" (Natalia)

Students like different subjects within science for various reasons. For instance, some of them are exciting for students while others are challenging, and this makes students more interested. For example, Priya stated that she likes biology, whereas Andreea finds science simple and enjoyable.

"I enjoy science very much, mostly I like biology classes and other sciences, so it is very enjoyable and I find it very interesting… chemistry is difficult … physics it is a bit hard but I still enjoy it" (Priya)

"They (science lessons) are easy and interesting" (Andreea)

The objective of this topic analysis was to examine how students feel and think about science, as well as their interests and challenges related to science.

4.2.1.2 Activities outside of school

This part of the data revealed related details about students' thoughts on out-of-school activities and whether they attend any science activities, read books/magazines, and so on. Amina and Priya said that they watch science-related shows, whilst Arjun stated that he gets help out of school to improve his knowledge and skills in science. However, Arjun's attendance of is partly driven by his family's willingness.

"I don't go to any out-of-school activities, but I watch shows related to science stuff" (Amina)

“I used to go to STEM club … I watch a series and it was about a doctor ... I watch like science documentaries” (Priya)

“The most science thing I watch is like crime documentaries,” (Andreea)

“I do tuition for science but nothing else” (Arjun)

4.2.1.3 Students’ thoughts about a science person

Data in this section reveal students’ thoughts about science persons. The shared details varied; for example, Amina described a science person as being interested and skilled in science, such as science teachers, whereas Natalia expressed that it refers to those who have aptitude for science and an opportunity to pursue further study at a college or university, where they might specialise in science, For Natalia, engineers, teachers, and architects could be science people. For Priya, a science person could make a valuable contribution to the improvement of the world by helping people.

“(a science person is) someone who is very involved … like a teacher” (Amina)

“It is a person who is really good at science and the person may study in science in college or university … maybe architecture, maybe engineering” (Natalia)

“I think like it means to me like it is more intelligent and maybe good at science, also maybe has interest in science … helps the world to go to be a better place” (Priya)

This analysis demonstrated that students hold a wide range of varied ideas about what it means to be a science person. These are reflections of their thoughts, shaped by their individual experiences and observations.

4.2.1.4 Students’ thoughts about scientists

Another important matter in this research was what students think about scientists. Because being a science person is part of conceptualising science identity; therefore, distinguishing a science person and scientists from the perspectives of students is important. Students stated that scientists are those conducting experiments who have a strong interest in the field of science. Amina and Natalia gave similar examples.

“I think like doing research and stuff … maybe researcher” (Amina)

“Scientists are people who are also good at science, also they are doing a lot of research, a lot of experiments” (Natalia)

Priya described scientists in a similar way to Amina and Natalia; scientists have science interests, a science career, and are successful. Andreea highlighted a characteristic of a scientist as having a strong passion for conducting research and discovering new phenomena. These ideas were also shared by Arjun.

"Someone who is interested in researching and discovering new things… scientist is someone who has studied it (science) for a long time and centres on one thing in science and has qualification" (Andreea)

The findings related to the theme indicate that students' understanding about scientists is that scientists work in science fields and also engage in active research and experiments.

4.2.1.5 Identification as a science person

Students varied in their self-identification as science persons. For example, Amina thought that she is not a science person. According to her, the criteria for being a science person is that she needs to have more interest in and engage with science, even out-of-school. For Natalia, she does not presently identify herself as a science person but would be one if she chose to have a science career.

"No (I don't think I am a science person) not really … I think I am not that interested, you know, I am not that involved" (Amina)

"No (I don't think I am a science person) … maybe, I will be (science person) If I decide to follow science, if I want to study it, doing research, reading books, doing things like revision" (Natalia)

Priya and Andreea stated that they think they identify themselves as science persons, but did not comment any further. However, Arjun clearly stated his interest in science but did not describe himself as a science person because he does not want to be in science fields.

"Yes, sometimes (I think I am a science person) [laugh]" (Priya)

"I prefer science and math as subjects but I also like English and like history and writing subjects but yeah I think I am a science person" (Andreea)

In sum, whilst some students think they are science persons, some do not presently identify themselves as science persons, but could be science persons in specific circumstances.

4.2.1.6 Recognition as a science person

Students shared how others recognise them as science persons. For example, Amina stated that her family thinks of her as a science person because she studies science at home.

“I think my family thinks I am a science person” (Amina)

Priya stated that her sisters see her as a science person, and she said that some people describe her as intellectual as well. Furthermore, Andreea said that she is recognised as a science person by her teachers, family, and friends. However, Arjun believed that although his teachers think he is a science person, his family may not recognise him as a science person because of his limited conversations with them about science.

“My sisters tell me I am a science person when I am doing something … Some people say that I am really intelligent in science …I am not very sure about teachers” (Priya)

“I think my family and friends think I am (a science person) … Yeah, I think they (teachers) also think I am a science person” (Andreea)

“I think my teachers do (think I am a science person) … But my family doesn’t think so much” (Arjun)

The students’ comments differ in their perspectives on how they are recognised as a science person by people around them.

4.2.1.7 Interest in science

The data about students’ science interest provides a detailed understanding of their level of interest and what could influence this. Using a rating scale from 1 to 10, the students were asked about their level of interest in science and why they think that a certain level represents their interest. For example, Amina said that her level of interest in science is around 4-5 out of 10; however, sometimes this interest may be lower, especially when she finds a topic difficult to understand. Students reported various level of science interest and reasons for the levels of their interest.

“Maybe like a 4 or 5 …. when I don’t understand, this is discouraging” (Amina)

“Ermmm, 7 … I don’t know (why) but because I can’t really be interested in one thing, like it can’t be like only science and nothing else …” (Natalia)

Priya was the one who expressed a high level of interest in science by rating it 8, which was because she thinks science is part of life. However, the rating is not 10 because she faces difficulties in understanding; this is similar to Amina.

“I think it is 8 … I practically enjoy like learning the things the surroundings, … but sometimes it is difficult to understand” (Priya)

Andreea and Arjun rate their science interest as 7. For Andreea, she likes to learn science and be part of science activities at school, but not out of school. Thus, her lack of interest in out-of-school science may lead her to think in this way. These findings indicate that students’ interest in science is influenced by factors such as individual choices, difficulties, curiosity and diverse interests in learning science.

4.2.1.8 Competence in science

This theme indicates what students think regarding their confidence. Natalia stated that she is confident in biology but when it comes to physics and chemistry, she is less confident. Based on her previous comments, the reason for the decline in confidence could be that physics and chemistry are a little difficult for her; therefore, she may correlate being successful with feeling confident.

“I think in biology I am a bit more confident in myself but I am less confident in physics and chemistry, it is in the middle … I actually enjoy with experiments, it allows me to be more involved” (Amina)

For Natalia, her competence depends on how well she does at science and her understanding of topics, whilst Priya stated that her confidence and interest levels are correlated. She highlighted an interesting point because, despite her personality, which means she is too shy to ask for help easily, when science is important for her, she makes an effort to get help. Andreea shared her experiences related to experiments by stating that she describes herself as a confident and quick learner.

“if I understand the topic then I am confident but if I don’t understand anything I am not confident” (Natalia)

“I feel like I am bit confident but then if I am interested in a certain topic and I am like I am flying … at the end of the lesson I try to tell my teacher like ‘oh I don’t understand the certain topic’ I am trying to make that move but sometimes it is not easy” (Priya)

“ (I am) pretty confident … I think like I am really into it (experiment) and I enjoy, I feel like I am getting there really quickly” (Andreea)

These findings show the impacts of being successful, experimentation, and support from teachers and family on students’ confidence in science.

4.2.1.9 Career plan in science-related fields

In this theme, the main discussion was about students’ career plans in order to elicit information about what they think. For example, Amina shared her willingness to be a dentist; according to her, this career plan is influenced by her interest in dentistry and also her mother’s encouragement for her to be a doctor or a dentist. Priya talked about her plan to be a doctor, and she is interested in biology; however, she also mentioned the difficulty and uncertainty she could experience due to her phobia and tendency to faint upon seeing blood. However, she is determined to go to medical school by dealing with her fear.

“I am interested in dentistry … my mum has talked, she kinda pushes me towards being like a doctor or dentist and stuff” (Amina)

“I also faint when I see blood so … I am really hesitant about that but I want to really go to medicine and health so yeah … I am still going to go to medicine, I don’t want to change anything … I would like to overcome my fear.” (Priya)

Andreea stated that she is specifically interested in the field of forensic science as a career plan.

“I was thinking forensic science, like crime solving side of science” (Andreea)

Arjun talked about the dilemma he faced between his family’s recommendation to him and what he wants to do. Whilst he would like to have his own business, his family wants him to study medicine. However, even though he likes science, he does not have a plan to study medicine.

“Maybe starting a new business or something … They (parents) said be doctor but I don’t really enjoy doing things like that” (Arjun)

Natalia was the only one who did not have any career plan at that time. When talking about students' career plans, they highlighted their interest and what they want to do; they also mentioned the impacts or support of their families regarding their career plans. Furthermore, as emphasised by students, the recommendations or supports of families are meaningful or taken into account when these match with what they want to do.

4.2.2 Theme 2: Gender and Science

4.2.2.1 Gender bias in classroom settings

The impacts of gender in classroom settings are explored in this theme. Amina shared her experiences related to gender-related biases, such as the possibility of facing more severe judgements when she makes a mistake. Andreea also shared her experiences related to gender-based behaviours or attitudes; to deal with these sorts of behaviours, she chooses to ignore them and believes that those students who have gender biases will change as time goes on and will regret what they have done.

"Some or majority of the boys you know they think that they are smart and so like then they leave you out when you are doing any practical thing. You know that can be a little bit discouraging and I get frustrated … kind of because I am a girl, I feel like if I put something wrong or if I get something wrong I feel like people more likely to see me so dumb" (Amina)

"I have heard like stupid comments like 'go back to the kitchen' … I don't take it personally, it is like I don't get so upset about it … if you like tell them (to teachers)‘ they (teachers) definitely react … I can just ignore them and tell them 'boys this is stupid and just stop'"(Andreea)

4.2.2.2 Perceived gender roles in career choices

Regarding the relationship between gender and career choices, four students just stated that they do not think there is any influence or relationship. Natalia also did not think there is any influence or relationships, but commented about this matter by stating that she thinks some occupations are appropriate for men because of their capabilities or are suitable jobs for women, such as being a doctor, a dentist, or a teacher.

"I think it (gender) does not impact me at all … but I do think some jobs, like engineering, are seen as roles that women are not considered capable of doing … (for females) like dentist, doctors maybe teachers" (Natalia)

4.2.2.3 Evolution of gender dynamics in science

Whilst talking about gender and their experiences related to science, changes in gender dynamics emerged as an interesting point. For example, Priya and Andreea talked about the evolution of gender roles and women in science, noting awareness of the historical dominance of men in science. Also, Priya mentioned her concerns about potential gender bias due to a higher male presence in university classes. However, this detail demonstrates that students' confidence and determination could help them overcome gender-related challenges in science fields.

"I feel like in the old days like there were lots of man-dominated, but I think now I feel like the world is like a little bit improved, so I don't have any fears going into science … I feel like I am just gonna ignore it (if there are more men in class) because there is nothing to do but I am still going to study well" (Priya)

"Women in STEM are quite new and more, so it's still changing" (Andreea)

4.2.2.4 Impact of gender on interest and competence in science

In terms of the relationship between gender, interest in science and competence in science, only Andreea shared her thoughts. She stated that she has female friends who lack interest and competence in science; however, she believes this is not directly linked to gender but rather to individual preferences and personal factors.

"I do have a friend who is a girl and not as confident and not as interested in science but I don't think it has anything to do with gender, religion, or ethnicity, but I think it is their personal interest" (Andreea)

4.2.3 Theme 3: Religion and Science

4.2.3.1 Relationship between religion and science

The relationship between science and religion was the main focus in terms of how students' religion impacts their science identity. Amina, a Muslim student, thought her religion did not have any influence related to science or her scientific studies; also, she said that she is encouraged to be acknowledged as a Muslim. However, even though she likes questioning science or religion to find a logical explanation, she finds her religion valuable and puts it first, despite valuing science.

"I follow Islam … I think Islam does encourage you to you know seek for knowledge… you know kind of science doesn't clash with Islam you know, and so sometimes you just squish because you don't wanna stay away from your religion … I like to question something in science that I maybe like it makes me question my religion, you know I am bit you know kinda put off like that … I try to see in a logical way of thinking (when religion and science conflict). But I always have to remind myself that my religion comes first to me" (Amina)

Natalia said that she is a Christian; regarding the positionality of the student between her religion and science, she usually keeps faith and science separate.

"I believe in Christianity … It (religion) is not influence me at all, it is not like forbid me to study science … that (religion) does not impact me at all [laugh]" (Natalia)

Andreea is an Orthodox Christian, and her faith does not change her beliefs in science. In other words, she wants to find a link between science and religion and tries to accept both at the same time. However, when there is any conflict, she prefers to believe in facts and science, but not abandon her faith.

"No, I don't think my religion impacts science, but science would impact my religion because I believe mostly facts and mostly science… I don't want to believe in one or the other, like I wanna believe both at the same time and it made me more interested in finding out how I can do that … I am Christian, an Orthodox … I kinda make up my mind which I think is more reasonable and which is more logical because I am like more logical person (Andreea)

Arjun said he is now a Hindu but does not think that makes a difference. Therefore, he did not comment about these. In this part, the information provided by students revealed two different perspectives and instances about how students think about religion and science, and also how their perceptions or values influence their standpoints.

4.2.3.2 Religion and career plan

Regarding religion and its impact on the science career plans of students, most students did not comment, or they just stated that they do not think religion impacts it.

Only Priya, a Hindu student, shared her concerns about potential effects such as exclusion because of her religion. However, she also highlights that her family knows her science interest and career plan; therefore, they provide support by introducing relatives who work in science fields to share their experiences with her.

"I believe in Hinduism … maybe a little positive because when I get to work in the area, it depends on the people I will work with, maybe I will work well together in the team or maybe negative because other people might like not involve me because of my religion… my family and relatives know that I like science and they help me with like for the future plans … Like one relative of mine is like a dentist and so one relative said me to talk to her, she knows the experiences of the field… my family has not been concerned about that and there are other relatives that have been in science line, so there is no concern about that." (Priya)

4.2.4 Theme 4: Ethnicity and Science

4.2.4.1 Ethnicity's influence on education

During the discussion on the impacts of ethnicity on the science identities of students, one theme that emerged was ethnicity's influence on education. Amina expressed that she does not feel any influence of ethnicity in her life. She mentioned her mother's support for her to be a high achiever and pursue a good job. This is similar to the way in which some cultures value high-status careers.

"Ermmm, I don't think it (ethnicity) affects me personally because my family is open-minded, but culture can play a part in how you are involved in science … For myself, I am encouraged … my mum, she is always telling me you know aim for the top grades, you know she actually pushed me towards the direction of taking triple science. … I think maybe just culture, it plays a part because, you know people want their kids to have highly paid jobs and you know they need high scores for that" (Amina)

4.2.4.2 Ethnicity and science interest

This section about ethnicity and science interest shows that students thought there is no influence of their ethnicity in their science interest. For example, both Natalia and Priya clearly stated that ethnicity has no direct influence on their level of interest in science.

"(I am) White … and I don't think (ethnicity influence my science interest level" (Natalia)

“(I am) Indian … no, there is no ethnicity influence for me …” (Priya)

This might be because of the divergent ethnic background of the school, which was also mentioned by the science teachers during their interviews.

4.2.4.3 Career aspirations and ethnicity influences

Regarding career plan and impacts of ethnicity, Priya shared her thoughts and experiences. According to her, the career plan she would like to have is also what her family wants her to do. However, she wants to study medicine because she wants to and is therefore not influenced by her family’s willingness. Also, she addressed the encouragement or speech of family members about being doctors and the expectation that she would help them later in their lives.

“As an Indian I feel like my parents have done a lot and tell me to go to medicine but it is just my interest so that is why I want to be a doctor … they told me to go to doctoring and then they said that you can look after me often, especially my grandads … but it is just my own interest … that is why I picked the science line” (Priya)

Andreea talked about the impact of her Romanian heritage on her passion for science, even though she faces potential challenges such as discrimination. She expressed that with her interest in science and her own determination, she could face and deal with all difficulties.

“I am Romanian” … “I think it (ethnicity) makes it a little bit harder because there is still some like discrimination and stuff but I don’t think it highly influences” (Andreea)

4.2.4.4 Theme 5: Intersectionality of Gender, Religion, Ethnicity, and Science Identity

As a final theme and focal topic of the research, this part analyses the intersectional effects of gender, religion, and ethnicity on the science identity of students. Despite each student’s understanding being different regarding whether the students have a science identity, the impacts of gender, ethnicity, and religion on students ’science identity varied. As students stated during the interviews, their parents value education and want their children to have successful careers, sometimes in science. The encouragement to pursue specific careers, such as being a doctor or dentist, exists because these roles are viewed as high-status jobs within their cultures or ethnicities. All the students interviewed highlighted that they will do what they want as a job regardless of what their parents want them to do; however, if students’ career plans align with their parents' expectations, this is good for them; but if not, students showed determination to have a job that they want.

Within the conceptualised framework of science identity, all five students interviewed displayed high interest and confidence in science and a few have science-related career plans. Arjun and Natalia are interested in science and confident in it but while Arjun does not have any career plans in science, Natalia does not have any career plans at that time. For three students, identification and recognition as a 'science person' differed. For some, their self-identification depends on certain factors, which are based on their ideas, and they think they would be a science person when they match the criteria for being a science person. However, there is no standardised value or criteria for having a science identity because of different interpretations or understandings of what it means to be a 'science person'.

In terms of the effects of the factors considered on science identity, even though students mentioned that there have been changes, gender continues to impact the context of science. However, the students felt that gender did not influence their science identity within family or social environments related to their science identity, but they did acknowledge that gender influences their perceptions of certain jobs as more suitable for one gender over another. This could be seen as an implicit influence of gender on students. The gender discrimination the students experience in classroom settings may result from socially constructed behaviours; the social environments they have been in are influenced by their ethnicity, culture, and various values.

Amina expressed herself as a believer, but she felt that religion does not affect her as much as culture does because, for her, culture plays a more significant role in practising and being involved in religion. Also, she felt that gender leads her to be targeted as a female rather than for her religion. However, her thoughts about culture are part of her ethnic identity.

"I think religion really comes to it you know when I am like in a society like that more accepting about the religions, but like culture could play a big part depending on how involved some people are … and that leads to maybe a little bit discrimination you are gonna cross … I guess (regarding believing in different religions as females) there is similarity would be that we all get targeted by the boys … when we get something wrong it is more like you get made fun of" (Amina)

Natalia highlighted that she has not been told about gender, religion, and ethnicity, especially how to behave in certain ways or consider those in her life. Ultimately, Natalia has her own preferences to value and follow, such as being a science person as a female with her own way to believe in her religion and experience ethnic values, such as by choosing her career plans without hesitation.

"So in my social environment, I was not even told anything about how religion, ethnicity, and gender, and their effect my understanding of science, but I know some examples… For example, in my religion, women who are Christian may be expected to take on more feminine jobs, and gender roles can influence these expectations." (Natalia)

Andreea emphasized that a diverse school environment reduced discrimination, making ethnicity and religion less significant in shaping her experiences.

"At this school there are so many differences like backgrounds, religion, so no one really discriminates against each other because there are so many people who might have the same background as me or others" (Andreea)

Another important point is that students stated that they do not experience any ethnicity impacts in school because the school has a diverse student and teacher population. Even though I, as the researcher, tried to expand the discussion related to this topic during interviews, students did not share insights regarding their ethnicity or science identity. However, female students mentioned that they cope with gender-related issues by ignoring them, which is how they deal with the issue.

In terms of religion, every individual's experiences are different; as discussed during the interviews, such differences depend on religions and how religious the students are, as reported by students. When science is more valuable than students' religions, they can ignore their faiths or avoid being influenced by their religions. The intersections of religion and gender affect individuals' lives in various ways because some religions have different rules or expectations of women and men, such as the religious duties traditionally assigned to women, as mentioned by Natalia. Also, the interpretation and practices of religions across cultures and ethnicities may vary.

Therefore, the effects will differ for individuals who follow the same religion but come from different ethnic background.

Additionally, all students mentioned that diversity of the school in terms of the students' population creates a social environment that fosters inclusivity and reduces discrimination except gender stereotypes. Therefore, students shared their experiences related to ethnicity and religion's influences in their science identity as there is no such an instance within the school context; however, no students mentioned that gender stereotypes are sourced by culture so experiences were mentioned by students related to gender stereotypes within science context is the ethnic influence. Consequently, the details that students shared during interviews provide insights into how the relationships between gender, religion, and ethnicity impact the science identity of students. Although the research focus remains on the intersectional effects of gender, religion, and ethnicity on science identity, the influence of parents on students' science education should not be underestimated.

4.3 Science Teacher Interviews

The following table presents the main themes, subthemes, and codes created from the findings obtained from the analysis in this section.

Table 42 Themes, subthemes, and codes from science teachers' interviews

Theme 1: Science teachers' thoughts about being a science person
Being a science person as a science teacher
Being interested and/or passionate in science
Using the scientific methods and having problem solving abilities
Engaging in science-related activities
The perspectives of science teachers about what makes a student a science person
Interest and engagement in science

Questioning and analytic thinking
Competence and success in science
Choosing science-related subjects and pathways and/or as an optional subject
Theme 2: Gender and science
Gender and being a science teacher
Gender and being a science person
Gender and interest in science
Gender and competence in science
Gender and career plan in science-related fields
Theme 3: Religion and science
Religion and being a science teacher
Religion and being a science person
Religion and interest in science
Religion and competence in science
Religion and career plan in science-related fields
Theme 4: Ethnicity and science
Ethnicity and being a science teacher
Ethnicity and being a science person

Ethnicity and interest in science
Ethnicity and confidence in science
Ethnicity and career plan in science-related fields
Theme 5: Intersectionality of gender, religion, ethnicity and science identity

4.3.1 Theme 1: Science Teachers' Thoughts about being a Science Person

In regard to understanding what science teachers think about being a 'science person', the aim was to collect more detailed and appropriate data. Thus, teachers were asked about what they think when they hear the term 'science person', whether they think about themselves as science people, and about what they think what makes a student a science person. I was able to gather data by asking these broad questions that were relevant to being a scientific person, which is one of the important components of having a science identity. From the experiences of teachers in relation to being a science person, the gathered data led to a more detailed understanding of how science teachers think about the impacts of gender, religion, and ethnicity on being a science person. The following codes were generated:

4.3.1.1 Being a science person as a science teacher

The science teachers who described themselves as science persons highlighted characteristics such as using scientific methods, having problem-solving abilities, being interested in and passionate about science, and engaging in science-related activities.

Being interested and/or passionate in science

When Neha talked about her being science person, she argued that an essential element of being a science person is having a strong interest in science and passion.

"Well like from the things I said I really, ermmm, enjoy science, I am excited and passionate about it (science) (Neha)

Using the scientific methods and having problem solving abilities

Johan linked the idea of being a science person with the skill of using the scientific methods; thus, this approach influences his own perspectives.

“Why I think (I am a science person) because, I have read about scientific methods and studied that at university, and came to that conclusion (Johan)

Neha, Emily and Lucia emphasised that problem-solving abilities and critical and analytical thinking skills are crucial factors for identifying and being recognised as a science person. They hold the beliefs that these abilities enhance one’s capacity to confront the challenges faced in everyday life from a scientific standpoint.

“I’m able to solve a problem or look at something from a different angle, and quite observant, so these are all skills picked up from as being a science person” (Neha)
“Being interest in things and trying to solve problems” (Emily)

Engaging in science-related activities

Ethan stated that he takes part in science-related activities and actively engages in science-related events. He sees these engagements as connected to being a science person.

“I do think about science-related topics, and I engage in learning activities, and leisure activities which are science connected, so, yes I feel positively about being a science person” (Ethan)

4.3.1.2 The perspectives of science teachers on what makes a student a science person

In terms of getting to know or understand more about what science teachers participating in this research thought about being science people, three subsections related to science person were discussed with them. The last part is about what science teachers think when the central topic is students and their being a science person. Therefore, participating science teachers were asked about what makes a student a science person. The characteristics given below were mentioned by teachers during the interviews.

Interest and engagement in science

Science teachers highlighted that students' curiosity and interest in science are important components in their being science persons.

"You do start to see differences as they grow, in what they enjoy about science" (Neha)

"They have an interest, passion, engagement with science, for science's own sake as I suppose" (Ethan)

"I do have kids they come up because they are extremely interested in other topics and they come up with different questions, and asking questions, they just, they just love it" (Lucia)

When discussing what it means to be a science person, Sara emphasised the importance of students actively participate in science class. However, Neha highlighted another point related to distinguishing the reason for participation; for example, whether participating in science lessons is because of a science interest or because the student solely wants to do well in school.

" Like fully engaged in the lessons, always being hands up, always like knowing that that person has done further reading… that's cool wanna learn more in general" (Sara)

"when a student want to do well at school, but it doesn't necessarily mean they are science persons, so that have the interest beyond those, they are asking their interesting questions, those are asking challenging questions" (Neha)

In identifying a science person, both Neha and Leila considered students' engagement and enthusiasm in science-related extracurricular activities to be a crucial factor.

"Those that want to come into extracurricular science activities where we have science club … the students that go sort of above and beyond their class, all the students that bring something to you that they've looked outside of class" (Neha)

"Someone who is like 'aa Miss I did this at home'" (Leila)

Questioning and analytical thinking

According to science teachers, the ability to think analytically and draw connections is another key characteristic of science persons. The ability of students to analyse situations, build relationships, and raise questions were highlighted as crucial for their active engagement in science.

“I guess a science person is somebody who questions what you say and is able to make links between things.” (Emily)

“the student is processing and thinking about information and questioning what they don’t understand and trying to like, you could see that they were trying to put the pieces of the puzzle together so that to me is the science student” (Neha)

“Who have asked questions and questioned…. I have identified a few of them (as science person)” (Leila)

Competence and success in science

Science teachers’ thoughts about competence varied; for example, confidence in science is important, but Ethan had a different perspective, which is that confidence in understanding science is important rather than showing confidence by participating in class. Notably, Leila stressed social skills and their relations with and/or influence on being a science person by mentioning the impacts of COVID and the isolation period on students.

“I think you can have people who I would identify as science people but who may not be confident, you know their expression of their ideas, or the communication of their ideas, they might be personally confident in their understanding” (Ethan)

“You do need competence there, because if you are not confident enough to get your ideas to get into action, then that’s basically nothing, that would be for any person … Courage of Year 10 is really bad because of the COVID, so they did not have a transition from Year 6 to 7, … the current Year 10 I find it the social skills not good and they are not confident in science even because of the social skills are quite poor” (Leila)

Moreover, teachers discussed the relationship between being science person and students’ success in science, considering not only their academic achievements but also their general attitude towards science, cognitive abilities, and problem-solving skills.

“all students at a point or another in a lesson have a moment of success … I think that is really important. We are as teachers try to make it (science) so accessible, which is also really challenging but we are trying to make it accessible for every student who can experience that moment of success and can feel confidence in science.” (Johan)

“You have to distinguish between science person I was just saying and someone who is doing well in science exams. Because those are not the same thing” (Emily)

“Not necessarily high grades, which means that if you are a science person you might be just an excellent student achieving in every single subject, and you might even dislike science, they just have to do it” (Lucia)

Choosing science-related subjects and pathways and/or as an optional subject

According to Johan, when students become science persons, science teachers emphasise their abilities to choose science-related subjects and career pathways. This is due to the students determining their interests and plans to have a science-related jobs; therefore, they pick science-related routes for post-16 education.

“There are those kids in Key Stage 4, to be easier to identify kids who have natural interest in because they choose an optional subject and they choose triple science as an option and this is strong indicator that they have some interest in the topic, and in the subject because they have chosen it. If they choose to do more in science than other students, so that is strong indicator” (Johan)

4.3.2 Theme 2: Gender and Science

During the interviews, teachers were asked about gender, their opinions and experiences of being science teachers, the way students behave, any impacts of gender on being a science person, interest in science, competence in science, and career plans. These findings are highlighted in relation to the research questions, specifically how gender influences science identity of students.

4.3.2.1 Gender and being a science teacher

This part of the findings focuses on the impact of gender on the practice of science education. The gender impacts on being a science teacher is that female science teachers may encounter gender-related prejudices in how students see them. Actually, some teachers thought that this is about female and male authority clashes.

It may not be related to being a female science teacher, rather it is about being female. Further, five teachers highlighted that cultural background influences this impression about authority which is held by female or female science teachers. Notably, Leila mentioned that being a female teacher and being a female science teacher are different, as being a science teacher provides some authority due to the perception that people in science fields are intelligent.

"When a male teacher tells students to do something, they are much more inclined to follow those instructions first time if a female teacher would ask same thing in the same way" (Johan)

"I think my gender impacts on being a teacher in general, at this school anyway … we have a lot of misogynistic behaviour from students … I've never really thought my gender has prohibited me from following that path to be science teacher, a female science teacher" (Neha)

"there is a lower respective authority, because I am a female, that's not because I'm a science teacher, this because I'm a female… whereas instead of being a female science teacher, I think it's actually very powerful" (Lucia)

"in this school if you are a female standing there and we have got students who don't take female authority but if you are in that position I think they think that you are really intelligent for some reason …" (Leila)

In addition to all that was mentioned about the impact of gender on being a female teacher or female science teacher, another point that was also highlighted is that a science teacher serves as a role model. Lucia expressed her thoughts on the significance of obtaining a PhD for pupils. This, too, is part of teaching to give students ideas for further career options and broaden their horizons, as well as encourage women who study science.

"it is quite empowering for our students to have role models, especially when I tell them that I have got a PhD, so I also think that is a learning moment for them about what does it mean to have a PhD … having a science degree as a female, you know, the numbers are a bit lower, it is disappointing, but of course you can do it" (Lucia)

These data indicate that gender is a multifaceted element that significantly influences female science teachers in various ways. However, the instances given by teachers are outcome of bias or stereotypes, whereas the way of teachers mentioned they took these outcomes as opportunities to benefit to become and feel powerful in science-related fields or being role model for who would be in science-related fields.

4.3.2.2 Gender and being a science person

Teachers' perspectives on the relationship between gender and being a science person varied. For example, Johan stated that some individuals experience gender influence on physics classes by attendance, whereas Emily highlighted that while gender influence academic success but not being science person. On the other hand, Neha stressed that even the number of male students is bigger than female's, the number of female students who like physics is outnumber males. Johan and Neha are two physics-specialised teachers at the school. While they discussed gender in relation to students' positioning in physics and their science identity, I, as the researcher, need to clarify this based on the interviews. While more female students like physics, they do not take the A level physics. Regarding being science person independently from physics, both Johan and Neha mentioned that female students may be more recognised as science persons due to the presence of female science teachers.

"The students' gender impacts, it is especially noticed in physics" (Johan)

"I don't think it (students' gender impacts being a science person) does … boys did better in their exams than girls but regarding being a science person, you know, I don't think gender doesn't matter" (Emily)

"I think with the exception of the very few students who like physics I think actually in this school, girls are more, the females are bigger in science, even though we have more boys in the school, I think more girls and that maybe that's because we have basically a mostly female department" (Neha)

4.3.2.3 Gender and interest in science

The perspectives of teachers about gender and interest in science highlight the complexity between these. However, while discussing about gender and science interest, science teachers specified interest of students regarding science sub-subjects. For example, Johan and Neha shared their experiences about the lack of female students' interest in A-level physics courses, whereas Sara stated that female students exhibit more enthusiasm for chemistry and biology.

"We don't get a lot of female students who study physics at A level … A level physics classes are male dominated … in chemistry and biology, there are much more girls" (Johan)

"I think the boys generally are more interested in physics unfortunately" (Neha)

"in my physics lessons, there are more boys interested than girls… girls are like more interested in biology, and boys are more interested in physics" (Sara)

Moreover, regarding gender differences in science interest, science teachers mentioned various factors which may shape gender norms, their attitudes towards science or reasons of having interest in science. As stated by the science teachers, the degree of interest that female students have in science is impacted by a number of factors that are associated with their families and cultures throughout their school years. For example, Lucia mentioned various characteristics for girls such as interest, confidence, being strong females, or having strong minds to get what they desire.

"I do have actually a lot of girls which are very interested, and I don't know whether it is because they are just interested, or because also in the context they have to be strong, and it would be coming from their being confident and so this showing their interest … considering other conditions especially, especially for the girls in that you're able to fight what you want to do like, and want to choose freely" (Lucia)

"girls find biology fascinating because it is related to them, because it has got menstrual cycle and all whole hormones, babies, the plants, everything is like caring and like those subjects" (Leila)

4.3.2.4 Gender and competence in science

Teacher perspectives on gender and competence in science reveal variations related to being confident among students. The influence of personal behaviours and characteristics of students such as being shy was stressed by teachers. Gender-related self-confidence may cause the differences, but some females outperformed males, and they do not hesitate to show their confidence in science regardless of their achievement.

“I think boys are a bit more confident in science than girls…” (Leila)

Neha stated that while some females are strong and confident to show themselves in science lessons but some females are shy, even though they are smart and successful. This could be because of family issues or their culture. Additionally, she highlights that global developments also influence the confidence of young women in expressing themselves and achieving their goals. Also, Lucia stated that she encourages female students to support their development or success in science without any influence of gender. Both Neha and Lucia are highlighting quite important statements to mention in this research, which is to get to know how different values or acts are responded to by students and reflected in their lives.

“Some girls are very confident… some girls are often too shy, because they are like ‘I don’t wanna get it wrong, I don’t wanna seem silly’ and I still have some girls like that but it’s changing now … their gender (about females) is getting a lot of positivity through negative things happening … I think is really starting to make our girls feel more confident … they are thinking that they have a place in society that where their voices can be heard and should be heard then naturally in all areas including science” (Neha)

“I do have some girls who are very assertive… I do think that with our kids there is a bit of a problem with being a bit misogynist … we’re protecting the girls which are not quite there yet, or that do not have the family context that is teaching them, you know you don’t always have to comply with whatever the others are saying even if he’s your brother, you’re not his secretary… that is very difficult sometimes, because you know you’re in the context of the class, and you can’t make the rules but they are bringing those personal habits, and you will try to moderate that, but sometimes it is a bit difficult” (Lucia)

4.3.2.5 Gender and career plan in science-related fields

In relation to gender and career plans, science teachers stressed that gender has less impact on career plans in science for students because they think as long as student decides on a certain career they would not stop or change their mind because of their gender.

“I think it’s (gender is) becoming less of a factor for that career progression… I don’t think either of them will let their gender hold them back… it’s about how good you are for this job” (Neha)

Science teachers stated that the influence of gender on career choices has decreased due to social changes and increased options for women. They emphasised the importance of focusing on students’ talents and abilities rather than gender as a problem. Teachers aim to teach students that professional choices should not be influenced by gender, allowing them to choose careers based on their unique skills and interests. For example, in contrast to female representation in physics, Lucia highlighted that there were female students who would like to be engineers. Furthermore, Neha also mentioned that female science teachers can serve as role models, so female students may admire them and be encouraged to go further.

“I did have actually, recently quite a few girls telling me that they want to work in engineering, and I was like ‘oh that is actually good’” (Lucia)

“That(gender) is influencing them, changing them, having more female science teachers, and you know teachers with a PhD, like these are high achieving females… “(Neha)

“Girls definitely go for science more than boys, boys go for PE and sports, business, engineering, or product design, they may take physics but they need that … ” (Leila)

The findings highlight the complex role of gender in developing science identity with details.

4.3.3 Theme 3: Religion and Science

The impacts of religion in relation to science, such as being a science teacher, being a science person, having a science interest, having confidence in science, and having a career plan, were discussed with teachers. For some teachers, religion does not have any impact on these aforementioned elements, whereas other teachers thought the opposite.

4.3.3.1 Religion and being a science teacher

Science teachers’ ideas about science and religion can sometimes be challenging for them, but this does not affect what they teach or the way they teach. Johan and Emily said that it is essential to teach scientific information. Johan and Sara also said that it is also important to be sensitive to and accept different points of view. It is, therefore, considered vital for teachers to find a balance, according to Johan.

“I usually try to be very sensitive about these... it is equally as important to teach students that people can have their own beliefs and their own opinions about things … even if you don’t change your mind, that is fine, but you need to learn what scientists think about evolution and Big Bang theory, for example” (Johan)

“ We are scientists, and this is what we are learning in science … well your science exam is still going to be exam and you are gonna need this, you need to learn this. I don’t care if you believe or not” (Emily)

“I don’t necessarily get religion and science involved, for me personally it doesn’t make me feel uncomfortable; it’s just something that, you know, they need to learn, and they learn it” (Sara)

Neha mentioned the diverse school population, but at the same time, she stated her positionality related to her religion and being a science person. In comparing the two, she clearly stated that she kept them separated.

“Nowhere in my religion does it say that you must believe in God and not science. I’ve never heard that. Obviously, there is a belief in God. For me personally, it (religion) hasn’t really impacted my identity, as I keep them very separate, but my belief in God is a bit, I am not really (religious) … for me, science makes more sense” (Neha)

These findings underscore the influence of religion in science teachers’ experiences related to teaching science.

4.3.3.2 Religion and being a science person

This part of the study focused on how teachers feel about religion and being a science person. Johan and Emily were not sure how religious beliefs affect a child’s ability to become a science person because they preferred to not take religion into account when teaching science. However, Neha stated that students’ religious beliefs might make them less likely to question scientific ideas.

"I think sometimes that (religion-Islam) does hold them back a little bit, because … they are very scared to go against that sometimes. It's a shame that they're not allowed to explore" (Neha)

By contrast, Lucia and Leila shared their thoughts that religions have limited influence, while culture and society are more influential. They said that religious beliefs can cause issues in the classroom, but these issues are usually caused by society. Leila thought that this problem is caused by society because students tend to focus on cultural factors instead of making connections between religion and scientific ideas.

"The direct impact of religion, I have seen it limited times. I have seen cultural effects which are linked to it." (Lucia)

"I don't think religion has impacts (on being a science person)، but culture does." (Leila)

4.3.3.3 Religion and interest in science

Regarding religion and science interest, religion may have an impact on students' interest in science. Two science teachers commented on the relationship between religion and its impact on science interest. According to Sara, religion has some influence on distancing some students from learning certain topics. However, Neha highlighted other factors that influence science interest in different ways.

"I think their religion causes them sometimes to question science, but I don't think it influences their identity or their interest… I think we've also been through that, like what your parents tell you, and you believe in that, I think too young to fight against that" (Neha)

"I don't think religion has impacts, but there are certain topics, like sexual reproduction, and younger students, year 7 and 8, the Muslim and strict Orthodox and Catholic students were just not interested in doing anything about it" (Sara)

4.3.3.4 Religion and competence in science

Regarding competence in science, Lucia mentioned that it is mostly shaped by their familial and cultural upbringings. She also addressed that there is a lack of emphasis on highlighting differences in religious influences among students who believe in various religions or have different spiritual faiths.

"It isn't that I've noted that people coming from a specific religion are more or less confident. I think, more family, culture related" (Lucia)

4.3.3.5 Religion and career plan in science-related fields

Neha and Leila claimed that students' career choices are influenced by their religious views. Although Neha underlined the impact of religion on career plans at the level of being religious. Both teachers stated that career-related decisions are also impacted by the values and beliefs of their families and societies, ethnicity, and culture. Furthermore, Leila stressed that the interpretation or experience of religion causes some differences because of cultural influences. For example, she added that there are no gender-related restrictions to work in certain fields in Islam. In general, teachers agree that religions may have impacts on students' decisions about their careers; however, this may not solely related to their religions.

"I think the degree of religiosity can affect career plans … sometimes it's leading them (students) along the wrong career path, but they think that's what they have to do because of their culture. They think they should do it" (Neha)

"Women still are allowed to work according to Islamic teachings, but the culture says no … I think I am not saying religion is not affecting them but it is culture, but not the religion. As I said I don't think there is an effect of religion, I am not seeing any difference between Hindu or Muslim, or Christian person taking up science different to compare with someone who is not a believer of any of these… there was one kid who said she doesn't want to be a doctor, but then I was like okay, why? Because if it is their destiny, God decided to give someone this disease, that means we are intervening with the plan of God by providing them the medication… then when I saw her another time, then I told her, 'maybe God also gave you the power to heal, so that you can … if God wanted this person to die the person will die anyway' … but I don't think she was convinced by it, that she didn't want to do it anymore," (Leila)

Regarding the relationships between religion and being a science teacher, and religion and elements of science identity conceptualisation, these findings provided a detailed overview. In particular, the relationships between science interest, competence in science, and religion are quite interesting, as mentioned by science teachers. Various interpretations and experiences of religious rules and how these cause differences are highlighted by science teachers, and this is an important outcome of this part to be discussed in the relevant section.

4.3.4 Theme 4: Ethnicity and Science

The impact of ethnicity on being a science teacher and science identity were discussed with teachers; for some teachers, ethnicity does not have any impacts on these forementioned elements, whereas others thought there were impacts.

4.3.4.1 Ethnicity and being a science teacher

The findings in this part demonstrate the relationship between the impacts of ethnicity and being a science teacher. Teachers shared different thoughts and experiences; For example, Johan, Ethan, and Emily stated that they do not think ethnicity has an effect on being a science teacher, whilst Lucia mentioned that having Italian heritage and its relation to and representation in science is likely a booster for being in the science field or working as a science teacher. Moreover, Johan and Neha mentioned the existence of role models; the shared thoughts of teachers referred to the impact of ethnicity as a motivational component for students as science teachers from various backgrounds.

“I don’t really notice (any ethnicity influence on being science teacher) … I do think that it is important to kids at the school to have a role model with their ethnic background.” (Johan)

“I think being a role model, I think is important, it does impact because again students who are also Indian also brown can see that we can achieve something” (Neha)

“…where we were all told like in Italy, we have such a strong scientific background, like historically and in terms also of the education” (Lucia)

This part of the findings highlights the diversity in teachers’ perspectives on ethnicity and being science teachers, which is influenced by their personal experiences and the perspective from which they see and experience their and other ethnicities.

4.3.4.2 Ethnicity and being a science person

Different perspectives and ideas were expressed about the impact of ethnicity on students becoming science persons. For this part, some said that ethnicity plays a role, whilst others stated that preconceptions and personal experiences are influential.

Johan believed that the interest of Indian pupils towards science is shaped by parental influence. However, while the question and focus was about ethnicity and being a science person, Emily's understanding of being a science person is being successful in science so as she talked, she emphasised success in science, and she added that she thinks Somalians are successful and potential science persons. Leila highlighted that students' interest in science may be influenced by their ethnicity and culture. This section emphasises the many viewpoints regarding the connection between ethnicity and being a science person.

"Not a big thing I have noticed... I do think that lots of kids with an Indian background are interested in science and are influenced by their parents" (Johan)

"If we are going to talk about ethnic groups particularly the groups I have seen do the best in science, I don't know if it means they are science people, would be Somali students" (Emily)

"It (ethnicity) does, and also culture, I think culture rather than that (ethnicity)… but as a science person that does not make them different" (Leila)

4.3.4.3 Ethnicity and interest in science

Neha and Lucia offered different perspectives on ethnicity and science interest. Whilst Neha said gender is a bigger factor in students' science interest when compared with ethnicity, Lucia argued that the background of students significantly influences their interest in science, regardless of gender.

"It (science interest) is more influenced by ethnicity really, and what their backgrounds and I think that is a big factor for those students" (Neha)

"I have seen that both girls and boys who are interested in science, it might be more related to the type of background …" (Lucia)

Apart from backgrounds of students and its relationship with higher level of science interest, teachers highlighted that ethnicity does not influence science interest.

4.3.4.4 Ethnicity and competence in science

Regarding competence in science, science teachers did not mention a direct relationship between any ethnicity and confidence in science; however, they stated that students who are potential science people or have a science identity often exhibit high levels of confidence. On the other hand, an interesting point was addressed by Sara who stated that students' competency is affected by their languages and accents in that their ethnic backgrounds and first language might influence their self-confidence in the field of science.

"If their English is a bit poor or if they, they have like an accent or something… the ethnicity and accent whether they would just come from country or something does impact how engaged they are, not necessarily their interests, it affects their engagement and their confidence" (Sara)

4.3.4.5 Ethnicity and career plan in science-related fields

Regarding ethnicity and career plans in science, the comments from teachers revealed how ethnicity and society affect students' career plans. As some teachers specifically mentioned that influences sometimes stem from culture, which they distinguished from ethnicity; this research conceptualises ethnicity as including cultural values. Ethnicity is defined as a broader term on the literature review chapter. Therefore, when teachers mention culture, this will be covered in ethnicity if it is not specifically cultural interpretation of religion rules. In the case of religion and culture interaction, this will be explained particularly. Neha discussed the impact of ethnicity and culture on career aspirations; for example, Asian parents find science-related careers important, and they set an aim to pursue science jobs for their children. On the other hand, while some ethnic backgrounds find science important or is a source of courage to study science for students, sometimes ethnicity is a cause to not persistent in those fields. For example, Neha shared her experiences, highlighting the low number of black students performing well in science subjects when it is time to decide on a career-related subject education such as A-level science lessons. Similarly, mentioning on culture by Neha, Leila also referred culture as an influential element to be in the fields of science.

"Asian students because that is what their ethnicity demands of them, to be good at science… (ethnicity) is what influences at this school, their science identity, and that is coming from those cultures wanting them to grow into these fields, doctors, dentist, surgeon, engineer that's what they want …. in my Year 13, she's the only Black student, from that ethnicity, that is the only one in the last couple of years …. I think, yeah, ethnicity and having a black background come with a really big factor for students” (Neha)

“Could be cultural but women are expected, if a girl wants to be a doctor the parents will support her no matter what because that kind of things like looking after and caring... But a girl wants to go and become an engineer or pilot that becomes a very different thing because they, the parents, they, if she is gonna do that kind of thing she can’t look after the family because that will require hours that hours out of family time … that is the culture it is what they have being told by the family it is where coming or about their background, that has the impact ” (Leila)

Lucia and Sara also stated that students and their parents who are Asian have a specific motivation to encourage their children to be doctors, dentists, or engineers. Sara claimed that the strongest motivation comes from family. When the focus is on ethnicity and its impact on a career plan, ethnicity, culture, and parenting are all working together, and this impact may result in support for being in the science field or, conversely, blunt the enjoyment of science and interest in being in the science field.

“With the ethnicity, I believe that students with the Asian background, they want to become doctors and engineers, they have a lot of encouragement from their homes, so that is what they wanna do” (Sara)

“What I noticed I do have quite a few kids like they are oh I wanna be doctor … the doctors ones are generally from Indians and Bangladeshi kids … I think it’s a bit of an achievement for the family… what is associated with being a doctor in respect to the professional where they’re coming from” (Lucia)

4.3.5 Theme 5: Intersectionality of Gender, Religion, Ethnicity and Science Identity

During the interviews with teachers, intersections of gender, religion, ethnicity, and science identity were discussed. Some of these elements have intersectional impacts on science identity.. Notably, for some questions that did not cover all components which are the focus here were left without comments by teachers. However, all teachers shared their experiences and thoughts when the intersection of these research components was the focus.

Because of family standards, religious views, and cultural effects, especially gender roles, science teachers emphasise that these factors often drive many students towards choosing careers in science fields. According to Lucia, she addressed the gender and ethnicity influences in general and related to science as well. Moreover, teachers interviewed stated that occasionally some Muslim girls experience a different attitude from their parents. For example, as mentioned by Leila, boys have more flexibility to choose, especially in the science career pathway, because the gender roles direct them towards earning money as breadwinners, whereas girls are expected to keep the family together by caring for others and similar responsibilities. However, these teachers underscored that these differences occur based on the type of family. For some, it could be seen as rules of religion but this also depends on how people interpret religion within the cultural context or ethnic values.

"I am not completely sure, it is just science-related, because it is something that I think is cultural related in respect to the relationship between boys and girls… it is very much related to the fact that I am a female Italian science teacher in a school that has a very high amount of boys that are coming from cultures, for example, Middle East, it is even like Romanian culture, as there is the Italian ones which is very masculinist, so I do already come from a culture which is a bit like that, so I recognise this, and is it about science, I don't think it's about science it is an intersection, so it's very difficult to, to separate it" (Lucia)

"if it is a man, and he is becoming a doctor or a lawyer that is fine because he's a breadwinner … whether it is wrong in Islam… that depends on interpretations or what these cultures and ethnic background do with the same book (She meant Quran), with the same rules they decide that it's OK for the men and it's not okay for the woman but actually it is not okay for both … I have been here as I said 16 years now this school I have come across students who have been from the same country same religion same tribe even and one family promoted their kids to do it, boy and girl same rules… the other come from the same community, and they were like that's not allowed... So, it has happened and that's why I said it is religion is nothing to do with it, it's the culture in the ethnic background that comes from that that he's got the whole gender bias" (Leila)

Another interesting point was highlighted by Emily, she stated that ethnicity or religion may influence people as their being minorities. However, London is a cosmopolitan city, and people may not experience ethnic influences in that context within in their social environment when they interact; this could be different because everyone is part of various minority groups.

“when we look at like London is very different from the rest of the country. When we are talking about ethnic minorities or minority religions, I don’t think it exist in London … I had a few conversations with children, when they were open and told me like ‘yeah Miss, racism is like a massive thing but actually where we are, you don’t experience racism because everyone is the same as us’” (Emily)

Also, Johan mentioned that underrepresented ethnic minority girls, even if they are good at science, may struggle to continue science pathway. He noted that he has had only one Black A-level science student. In a different way, Ethan shared his experiences about when students need to go on field trips during A levels and some Muslim parents hesitate to allow their daughters because of the idea that students on field trips might do something that is against their values. These could be nuance examples of how intersectional influences are experienced by students in terms of their science identity or their science positionality.

“There are a few Muslim girls in my Year 11 classes, they are absolutely brilliant at science and have expressed the interest in it. I do hope … I do think their ethnic group is underrepresented in the scientific profession but they are really talented at it, and it would be shame if they perceive that underrepresentation as a reason for them not to do it, not to pursue a career or at least starting A level in science …” (Johan)

“Sometimes we have a residential trip for biology in 6th form, there are maybe one or two parents who don’t allow children to go, despite the fact it will mean those students fail part of their A level, because they don’t want their child to be away with members of the opposite sex…… those students are female, so religious Muslim girls, because the parents fear that they are gonna meet boys, but, on the field trip, the male and female students are segregated into different floors of the building for sleeping, so if they don’t have to mix at any point if they don’t want to (Ethan)

The teachers said that students, as girls and boys, face unique problems in their educational choices when they are put in situations that go against the ethnic, cultural, and religious values and beliefs of their family. For example, both Sara and Leila highlighted the special situation of Muslim girls in terms of having responsibilities for family duties or attributed goals as girls in the future, such as being mothers.

Ultimately, these findings showed that teachers were aware of how gender, religion, society, and ethnicity interact with each other and how they thought these elements affect the choices that students make about their education. Teachers also stated that they are there to step up when needed to talk to parents, explain situations for students, or encourage students by providing information and supporting them on their journey towards having a science identity.

"I think, being a Muslim girl is like something different, I think if you're Muslim boy or if you are not in a position of a Muslim girl, it is all because of the fact that your parents give you more freedom if you are a boy… still this idea in their head though when you finish college, you go and get married you don't need to go to university because your whole purpose is to have children … one thing I've seen is eastern Europeans, if you're in an Eastern European part such as like Romanian, I don't think that some parents care much about the education… they (these parents 'children) have no goals in life, they have no admiration towards anything … when I was saying about like being a Muslim girl, it's not very problematic but it doesn't apply to all the girls yeah, … among those (gender, religion, and ethnicity), I think family is the most important, one of the things that happened a couple of month ago, one of the girls, she was actually a high ability student because of some of the problems are happening at her house, her parents become very strict, not Muslim but, but their culture, culturally they had expectations, … and the child then decided to like run away from home which affected lots of her results" (Sara)

Overall, the data collected from science teachers about how, in their experience, gender, religion, and ethnicity impacts on the science identity of students offer valuable information that is helpful for accomplishing the research aims and answering the research questions. Although the number of science teachers participating was relatively small, they represent the majority of science teachers at that school with many years of experience.

Examples of gender-biased behaviours from students were mentioned by several science teachers such as difference between being a female teacher and a female science teacher. Additionally, some female teachers highlighted that sometimes their roles as science teachers are more challenging when male students have misogynistic mindsets and display behaviours according to their mindsets. Nevertheless, teachers stated that they have been careful about these types of behaviours, for example, when they suspect potential misogynistic attitudes, they take steps to minimise such behaviours and create a safe environment for other students, especially for girls.

The aforementioned situations may seem to focus on gender; however, this is a reflection of how individuals, who have different backgrounds and values, perceive men and women. Basically, the gender-based differences and behaviours could be outcomes of the understanding and interpretation of gender within ethnicity, in other words, this may be related to the intersection of gender and ethnicity.

When discussing religion, gender and science identity of students, teachers often addressed controversial and sensitive topics such as evolution and the menstrual cycle. Despite the responsibility of teachers to teach scientific information and evidence, almost all teachers mentioned that when they talk about religion and science together, instead of ignoring students' values or personal beliefs, they try to find ways to engage students academically by explaining the importance of learning this scientific information because they could be asked about it in exams.

Moreover, religions do not influence only the learning and teaching the mentioned sensitive topics, but they may also have impacts on their career plans. Because of the rules of religion in which students believe, students might choose not to pursue careers in medicine or may not be able to participate in science field trips; even though, a teacher pointed out that the rules of religion are almost the same for men and women, but religious interpretations and practices can vary across different cultures.

The final points to highlight in this part are the differences in the freedom and support given to boys and girls by their families, and the intersectionality of gender, religion and ethnicity. To sum up, the outcome of the interviews with teachers reveals that the science identity of students is not solely affected by their gender, religion, or ethnicity, but rather by the complex interplay of these factors.

5 Chapter 5: Analysis and Discussion

This chapter illustrates a comprehensive analysis and critical discussion of the findings presented in Chapter 4, focusing on how gender, religion, and ethnicity influence students' science identities through the lens of intersectionality. The analysed qualitative and quantitative findings are interpreted in relation to each research question and situated within the broader context of existing literature. Additionally, the role of parental influences is considered in this chapter as a key mediating factor. When analysing and discussing the findings, existing literature will be referred to in order to highlight any similarities and differences to deepen understanding of the complex and intersecting factors that influence the science identity of students.

Table 43 Research Questions, Data Collection Methods, and Key Outcomes

Research Questions	Methods to gather data	Key outcomes
RQ1: From the perspectives of students, how are students' science identities impacted by gender, religion, and ethnicity through the lens of intersectionality?	Interviews with students, student surveys, and interviews with science teachers	Gender is the most frequently mentioned factor for female students who experienced gender-related challenges in science classrooms. Conflicts between religion and science may lead some students to question one or the other. The diverse population of the research-conducted school reduced possibility of feeling excluded and fostered a sense of belonging and equity. Career aspirations were shaped by both religion and ethnicity. Gender, religion, and ethnicity intersected in complex ways, with female students at the centre. Those with potential science identities demonstrated an incredible sense of positioning — becoming stronger and showing strength and determination to pursue careers in the fields they would like to work in.

RQ2: Within the obligatory and voluntary identity contexts, how do students experience the impacts of gender, religion, and ethnicity on their science identities?	Interviews with students, student surveys	Within the obligatory and voluntary identity contexts, as expected obligatory identities of students tend to dominate over voluntary identities. Science identity is often secondary when compared to gender, religion, and ethnicity. In terms of developing obligatory identity to prioritise decision-making or any other consideration, religion is the most influential.
RQ3: How do science teachers perceive the impacts of gender, religion, and ethnicity on their science identity and their students' science identity through the lens of intersectionality	Interviews with science teachers	Individual influences such as gender, religion, and ethnicity impact students' science identity development in various ways. These include gender-related stereotypical behaviours, conflicts between science and religion, religion's influence on career aspirations, and the perception within some ethnic groups that science is important or associated with high-status careers. Intersectional influences of gender, religion, and ethnicity reveal that students experience science identity development in diverse ways—particularly among female students—that are not easily attributed to a single factor.

5.1 Research question 1: Perspective of Students for Their Science Identity, and How Their Gender, Religion, and Ethnicity Influence Their Science Identity Through the Lens of Intersectionality

This section discusses the key findings on students' perspective regarding their science identity and how various factors influence students' science identity. The data discussion will refer to existing literature to provide stronger insights into the association of variables, science identity of students, and how the complex interplay of these factors influences students' science identity.

5.1.1 Participants' Conceptualisation of Science Identity

In this section, where the main focus is to understand science identity development, the first thing to highlight and discuss is that students' thoughts about both a science person and scientist. The difference between a science person and a scientist is an important understanding that is helpful in terms of distinguishing a science person from scientist, and conceptualising science identity. For example, in terms of scientists, students had an understanding that being a scientist is related to doing research; at least a scientist is someone who is interested in doing research. The stereotypes related to scientists, which have been studied for decades, such as scientists being white males, maybe in lab coat (Ferguson and Lezotte, 2020; Cakmakci *et al.*, 2011; Finson, 2002).

On the other hand, in general, students agreed that a science person has a science interest, the skills to use scientific methods, is intelligent, and also study science during college or university and/or is planning to have or has a science-related job. Additionally, the career options available to a science person are not limited; students mentioned various jobs related to science. The idea that there are various job opportunities aligned with being a science person is important because this outcome was also highlighted in the questionnaire as a strong factor influencing career plans in science, which is a key component of science identity.

In terms of being a science person or scientists, none of the students mentioned gender, ethnicity, or religion. Understanding students' conceptualisation of a science person also provides them with a positive impact, especially once they think they are a science person because the characteristics they identify with reflect their own traits as science persons. The point underlined in the study by Hazari *et al.* (2013) is that self-identification as a science person supports the development of the science identity. For example, various views about being a science person were highlighted in the findings such as a student identified herself as science person occasionally while another one did not identify herself as a science person yet because of lack of college or university qualification. This aligns with the nature of identity discussed in the literature chapter, where the identity is seen as constantly developing and changing, with individuals having multiple identities.

On the other hand, an inconsistency between students' understandings of characteristics of a 'science person' and their own personal traits may create confusion or hesitation in self-identifying as a science person, which could affect their confidence in science and their willingness to pursue science careers. For example, Atkins *et al.* (2020) conducted research about mentorship effects on science identity for minority groups, and one participant shared his feelings about his identification as a scientist; according to him, he felt like a student at that moment, but wanted to work as a scientist. This is related to how people interpret situations, terms, and concepts in diverse ways. Also, identification as a science person, which is a sign of having a science identity, contains another aspect of seeing oneself in the field of science or reporting a sense of belonging and this could help individuals to have a stronger science identity. These aspects are supported by the literature; for example, Chen *et al.* (2020) found that science identity influences a sense of belonging, and science identity has impacts on performance; the influences within these could be more complex and not unidirectional; in other words, science identity, performance, and a sense of belonging could bolster each other.

Regarding self-identification and recognition reported on students' surveys, the difference between the number of students who identified themselves as science people is larger compared to students who are recognised as a science person. While the low number of students thought that their science teacher thinks they are a science person, according to the factor analysis results related to this component of science identity, science teachers' recognition influence on being science people is the least strong compared to others. This is a notable outcome; participating students may consider their science teachers as a science authority, and their level of being a science person may not match science teachers' criteria for being a science person. From an individual perspective, during an interview with a student, when the discussion topic was about being recognised by teachers as a science person, she asked her teacher about this. She was pleased to hear that her science teacher recognised her as a science person, and this recognition might serve as a motivational source for her to continue her involvement in science.

Being recognised as a science person could reinforce students' science identities; such recognition represents being noticed as a certain kind of person. This is one of the key elements in the adopted approach to identity, as discussed in Gee's identity conceptualisation in the literature review chapter. According to Çolakoğlu *et al.* (2023), effective mentorship and recognition of students' efforts and interests play a crucial role in fostering a positive STEM identity, especially among minority groups. For instance, Priya shared her recognition through her scientific abilities in her daily life. Noticeable social recognition from family, teachers, and peers could reinforce such belongingness; it could also boost students' competence and persistence within the areas of science, sometimes specifically for minority students, sometimes for people who are interested in physics (Starr *et al.*, 2020; Aschbacher *et al.*, 2010; Cwik and Singh, 2022).

Family recognition showed a strong association with science identity, according to the quantitative data of this research. Similarly, during the interviews with teachers, they often mentioned that family is an important factor in terms of valuing science education, success in science, and having a science-related career plan. The importance of social recognition is helpful for some women regarding science identity development (Roberts and Hughes, 2022). Therefore, being recognised by significant others — such as family, friends, or teachers— plays a crucial role in the development of female students' science identity and in supporting their academic journeys, especially in traditionally male-dominated fields like science. Research conducted by Hill and Tyson (2009) and Zhang *et al.* (2011) highlighted the impact of parental involvement on children's educational achievements, with active parental support creating an encouraging context that could motivate female students to be more confident and successful. Similarly, peer interactions significantly help female students in terms of dealing with challenges and feeling welcomed and capable in their abilities (Marcenaro and Lopez, 2017).

On the other hand, for some students with an obligatory science identity, recognition and social acceptance may be less important. For those who are affected by their gender, religion, or ethnic values with a less strong obligatory science identity, social acceptance can provide a supportive environment that help them gain confidence and persist in science. Similar findings to those mentioned above were presented in the research of Jackson *et al.* (2019); who highlighted that for women who have a high level of science identity, recognition in the field of science is not as effective as it is for women with a lower level of science identity. For example, the case of Andreea can be an appropriate instance regarding this matter. Recognition by people around her may not be important for her due to her being assertive and determined. Andreea shared her experiences regarding gender-related issues in class, being targeted by some male students who told her ‘go back to the kitchen’. Reacting such remarks may not be feasible for every female student; however, Andreea stay strong and confront such stereotypes. Andreea’s positionality toward various values and her ignorance about how people recognise her may stem from her perspective and experiences related to her ethnicity (more specifically, her nationality); this will be discussed in the ethnicity related section.

From the frequency analysis of data, one-third of students stated that they are interested in science, whilst their interest and being part of any science-related activity, such as seeking more information, understanding the world through science, reading and watching something related to science, varied somewhat. For example, the number of students who like to read something related to science was less than half of the number of students who are interested in science; only 11 students who think science is helpful to understand the world were lower than for any other statements. The measurement of interest in science through factor analysis shows that reading books related to science is a strong indicator of having interest in science. However, the statement that science is helpful to understand how the world works is the least strong indication of science interest. However, one of the interviewed students, Priya, expressed her high level of science interest and commented: ‘It is interesting to know the science behind everything’.

Another construct of science identity is competence in science. Around half of the students who filled questionnaire think they are confident in performing practical work and exhibit good performance in science activities. The scientific interest and competence of students are crucial for their development of a science identity (Carlone and Johnson, 2007; Aschbacher *et al.*, 2010). Developing and pursuing a career in science is related to an interest and belief in science (Wang *et al.,* 2023). For instance, some students shared their thoughts and experiences about the support provided by their family, friends, and teacher. Moreover, the support provided and the creation of an environment for students to feel more comfortable were mentioned by teachers, Neha highlighted the importance of paying careful attention to her female students to praise them, and Lucia explained how she keeps them in groups in which females could feel safe and comfortable. In other words, social acceptance could help students to deal with external barriers such as feeling that they belong to the fields.

The last component of science identity is having a career plan in science. Around one third of students have a science-related career plan; most are aware that a science qualification is helpful in obtaining various types of jobs. Factor analysis confirmed that career aspirations strongly influence science identity of students. This aligns with Hazari et al. (2013), who stress that students who identify themselves as science persons can establish a relationship with their careers and are more likely to take part in science activities and succeed in scientific fields.

Whilst the conceptual components of science identity are important, it is also essential to explore how gender, religion and ethnicity influence it – beginning with gender.

5.1.2 The Influences of Gender on Science Identity of Students

According to statistical data, for participating group of students, statistical analyses identified the significant associations between expected gender behaviours, the importance of gender in career decision-making, and parents' discussions about gender and career. However, not all associations were significant. Moreover, most of the participating students had not talked about gender and their career plans with their parents. On the other hand, gender is important influence, to some extent, in career decision-making, and participating students generally expected to behave in an appropriate way according to their gender. The complicated outcomes may reflect either their lack of awareness or that gender is not considered as an important variable that could affect the career decision through the discussion with parents. Interestingly, this contrasts with findings by Stoet and Geary (2018), who found that gender may not play a part in determining a career, as parents' attitudes and conversations are significant in determining the shape of a student's career.

Moreover, my research participating group also showed a different trend regarding the gender and the number of students who identified as having a science identity. For example, the research of Bian *et al.* (2017), where it was demonstrated that there is a substantial influence of societal expectations and gender stereotypes on girls' self-concept and interest in fields related to science. The findings indicate that gender differences exist in science identity. While both male and female students are mostly uncertain about their science identity, males are slightly more represented in the 'No science identity' category. Only a small number of students across all genders were classified as having a science identity while there is no specific gender gap among students who have science identity. There may be students who are interested in science, confident in it, or have a career plan but when the final science identity indication was calculated they may not be included in the group of those having science identity. For example, these findings align with previous research suggesting that whilst both genders can have similar levels of interest and competence in science, confidence and career plans could be influenced by various factors such as societal and cultural norms (Hill, *et al.*, 2010; Sadler, *et al.*, 2012).

5.1.2.1 Female Students' Experiences in Science-Related Settings

One of the main factors could be individuals' interest in science in relation to their science identity (Vincent-Ruz and Schunn, 2018; Maltese and Tai, 2010). The relationship between gender and science interest is affected by personal preferences and individual differences, sometimes not dependent on the social environment. For example, Andreea mentioned that several female friends of hers were not into science simply because they did not like the subject, and the reason for this might not be their gender but personal interest. This indicates that the effect of gender upon scientific interest is primarily determined by individual differences. These results imply that gaining insight into the influence of gender on science interest is a matter of individual differences and personal preferences, such that scientific interest and achievement are influenced not only by gender but also by different factors, individual motivations, and the support that students receive (Kang *et al.*, 2019). Feeling a sense of belonging in science-related fields, recognition or social acceptance of individuals, or appraisals of what students are interested in could change the level of students' interest in science, their career plan, and the development of science identity; none of these elements work in a one-way system as they all influence each other to reinforce science identity (Kayumova *et al.*, 2024; Atkins *et al.*, 2020; Ikonen *et al.*, 2017; Jackson *et al.*, 2016).

Despite personal interest playing a role in science identity, external factors like gender stereotypes also influence students' engagement with science (Jackson *et al.*, 2019). For example, female students mentioned listening to the comments related to gender biases or feeling excluded by some boys during science activities, but they would just ignore comments coming from male students. As stated by Amina, female students developed coping strategies for gender bias as they stressed that they try to ignore gender-biased behaviours as much as they can. On the other hand, as shared by a student, she had a strong science identity and unwavering confidence in what she does when she engages in arguments related to gender related stereotypes. She recognises this gender bias from personal experience, so she responds by saying they need to stop it.

Another gender related influence related to science interest is addressed by Amina, specifically, that boys dominate practical work, demotivating female students. This is aligned with the existing literature, which reports that gender bias in classroom dynamics disrupts female students from developing a scientific identity and negatively affects their participation in scientific activities (Sadker *et al.,* 2019; Archer *et al.*, 2013). Conversely, some studies found that females' science identity could be supported by various elements, such as an opportunity to show their interest in science, recognition by people around them, or feeling welcomed in any science-related activities or environments (Jackson *et al.*, 2019; Roberts and Hughes, 2022; Marcenaro and Lopez, 2017).

For example, two students mentioned that they feel more comfortable in groups where they feel accepted by friends, regardless of gender. The importance of friendship was studied and highlighted in a different context with a different participant group - university students - by Read *et al.* (2018). However, the focus on the importance of friendship in terms of feeling comfortable, obtaining emotional support, or coping with stress, while highlighting the impacts of the social dynamics like gender, ethnicity and so on is also a key point in my research. A sense of belonging could be one of the major elements in educational institutions and workplaces, as addressed by many students and teachers in my research as well. This sense of belonging can be developed through making friends and feeling accepted, as highlighted in my research.

Students’ perspectives on the function gender performs in career choice demonstrate how cultural gender role norms can influence them. The effects on students’ lives are various; as mentioned previously, whilst boys could discriminate against female presence in science fields even during compulsory education, the structured perspectives of females could affect their standpoint with regard to career plans. For example, according to Natalia, the engineering career is for men, whilst that of dentistry and teaching is for women. This is consistent with the studies of Ceci and Williams (2011) and Wang and Degol (2017); who found that gender norms limit opportunities for women in STEM, consequently resulting in female underrepresentation in this field of work. However, as a result of being unique and having various understandings and values, not every female student experiences gender influences whilst deciding on their career. For example, one would like to be a scientist working in forensic science and another one will be persistent to attend medical school because these are what they want to do. Despite their early ages, these students show determination about what they want to do, and face difficulties that many boys may never have experienced. This instance places an even greater importance on challenging gender norms to empower and support women in science-related careers and increase the female presence.

The final important point in the discussion related to gender and science is that almost all female students, as well as teachers, mentioned changes regarding equity and the inclusion of women in science fields. This highlights how women’s movement for equal rights and representation in science is important, even for secondary school female students. This allows them to envision more women in the field, and more will be included. This is encouraging because the feeling of being lonely or excluded can demotivate them from developing a science identity.

To sum up, as discussed in this section, some findings align with the existing studies; however, interviewing students at an early age provides valuable insights into their competence in science and their ability and willingness to persist in the field of science. Therefore, regarding the gender influence on the science identity of these students, my research reveals that a sense of belonging and determination can eliminate the negative influences, while boosting the perception of female students’ confidence and determination. The findings thus emphasise the role of gender norms in education and career choice and underline what needs to be done to secure gender equality.

5.1.3 Religion and Science: Conflicts, Overlaps, and Career Aspirations

This research reveals that religious beliefs are influential in making career plans for the students who participated in this research, similar outcomes and assumptions in the literature support this outcome. For instance, Duffy and Dik (2012) found in their study that religiously oriented churchgoers are likely to pattern their careers according to what they think would be meaningful and aligned with their religious values and beliefs. The research indicates that people, through their religious affiliations and religious teachings, may think about potential careers.

A study by Saucerman and Vasquez (2014) also identified that the vital role of religious support networks, such as family and community, can radically influence career choice by offering both support and resources that align with individuals' spiritual values. The study underlined that religion and family are important components of students' lives and their science identity. Although the science identity and religious influences were not directly measured through a survey, questions were asked to find out how religion may influence one of the key elements of science identity which is career plans.

Furthermore, in terms of religion, the impact of religion on decision-making about a career was statistically significant. Whilst the type of association did not show the tendency of the relationship, a check of the crosstabulation table revealed that when the importance is greater, its influence also increases. The influence of religion on career plans may differ from student to student. For example, this is consistent with the results of studies Chenot and Kim (2017) and Scheitle and Dabbs (2021), the importance of values or the level of being religious changes the influences of religion on career plans. The study of McClure and Riedel (2021), the results revealed that one's religious beliefs are typically influential on both work values and career selection among believers. This is also exemplified in my research, where religion emerges as a motivational source for pursuing education, a reason behind choosing certain career paths, and a basis for avoiding career that conflict with religious values. For example, Amina, a Muslim female student, is encouraged by her religion to seek education and aims to pursue a career in science which enables her to help people.

Moreover, religion's influences may not be only limited to compatibility of religion and science-related field or acceptability of scientific information and contexts. For example, a student raised an interesting point about her hesitation for being isolated due to her religious beliefs. The important case of being identified and recognised with a value or background and social acceptance aligned with the literature. For example, such group-based identification could enable people to feel comfortable and belong, which is important for mental health (Jetten *et al.*, 2017), and social acceptance is important for students (Jackson *et al.*, 2019).

However, being a minority as a follower of a particular religion is also a concern for individuals who worry about feeling a sense of belonging in the field. Therefore, religious beliefs could influence career plans indirectly, such as when there are conflicts, and religions cause hesitation when it comes to questioning and scientific curiosity. This may lead to people losing their interest in science and their aspirations to work in science fields (Jones *et al.* 2020; Ecklund and Scheitle, 2017; Leicht, 2022). When compared to the large number of students who stated that religion was important to them when making career decisions in the quantitative part of the research, students who participated in the interviews found that religious beliefs did not impact their career choices. This could be because the interviewed students might be ones who do not think religion is important, or they made a career decision that is compatible with religion and its practices.

Findings show how religious beliefs shape scientific curiosity and efforts when students face the intersection of religion and science by valuing one over another. This has also been mentioned in a different research context conducted by Jochman *et al.* (2018), which explored the impact of religion and political perspective on biological knowledge, interest, and science identity. According to the study, religion could work like a "perceptual filter" (Jochman *et al.*,2018, p. 585). Thus, religious beliefs could affect trust in scientific knowledge and understanding and learning science (Jochman *et al.*, 2018); especially for areas of conflict between religion and science, they could be summarised with questions like "where do we come from" and "where are we going" (Leicht *et al.*, 2022, p.232). In terms of influence of religion on science identity on students, my research bring the controversial discussion about creationism, evolution, and religious bias towards science. This is the discussion of creationism and evolutionism; each can be believed by different people without a clear distinction between being a believer or a scientist.

According to Ecklund and Park (2009), religious beliefs could both support and limit scientific careers based on the specifications and values of the religious groups. My research findings also established a significant association between religion and the importance of religion to students, as well as between parents' discussions on religion and the importance of religion concerning career plans. The compatibility of the perceived conflict between religious beliefs and scientific concepts could be a factor significantly influencing individuals' worldviews and students' attitudes towards science (Baker, 2005; Barnes *et al.,* 2017; Gondwe and Longnecker, 2015; Jochman *et al.*, 2018). However, even if they find their religion important, students in this research demonstrated that having a science identity as a religious person is possible. As mentioned by participating students, they believe in and sometimes practise their religion, but they are still interested in science, or in having a science-related career plan. Only one of the students stated that when she needs to choose between science and her religion, her religion takes priority.

This is addressed by McPhetres *et al.* (2021), people can simultaneously hold both scientific and religious beliefs, indicating that religious beliefs are not always linked to negative attitudes towards science across different cultures. For example, a Christian student shared her experience, stating that although she follows a religion not aligned with evolution, she still prefers evidence and science. However, she highlighted that she still believes in her religion, not abandoned it.

The impacts of religion could be softened or eased by support from people around them, such as family. For example, one student mentioned that her family introduced some relatives who work in science-related fields to make her feel confident that she would not be isolated in the field of science. This support from family is also highlighted by Bryant and Astin (2008) and Scheitle and Dabbs (2021) who found that it is possible to weaken the effects of religion by using social and family support to encourage people to pursue science careers.

The discussion related to religion and science identity addresses how students' religious beliefs affect their science positionality. In short, students' and their parents' religions may affect students' science identity in various ways, and each individual's experience is unique.

5.1.4 Ethnicity and Science

The diverse ethnic background of students provides a broad range exploration related to ethnicity influence on science identity. In terms of ethnicity influences, family impacts is also an important part of this theme. Statistical analysis confirmed significant associations between ethnicity, parental discussion about ethnicity, career considerations. This aligns with the literature, Turner and Lapan (2019), whose study revealed that family factors significantly influence science career interests among adolescents. There are variations in science identities across different ethnicities, and significant differences in interest in science were observed among students from other ethnic groups. However, Asian students were the majority in terms of having a science identity, similar to Carlone and Johnson's (2007) view that ethnicity has much to do with a person's scientific identity. However, while the number of Asian students was higher than that of any other group in the total population, the representation of students who have a science identity remain diverse. This contrasts with the literature that suggests minority groups are underrepresented in terms of having a science identity.

Although the literature highlights the ethnicity influences in science identity of individuals, the survey results in this study did not identify a statistically significant relationship between the variables examined. This significant finding may be attributed to the context of the research, which was conducted in a diverse school where students do not feel like a minority, as the rest of the students are also from other minority groups. Indeed, the only significant relationship found was between parental discussions on ethnicity and the importance of ethnicity in career decisions. This would seem to suggest that school children's perceptions and career choices are primarily influenced by parents, as found by Riegle-Crumb *et al.* (2011).

The findings pertain to the impact of ethnicity on education, science interests, and career plans. For example, students' educational experiences are significantly influenced by their ethnic backgrounds. An interviewed student identified the role her ethnic background plays in the academic success that she claims has marked her life; she mentions her mother's high demands and ethnically rooted academic success expectations. This is supported by literature documenting ethnicity and cultural expectations as essential and significant in shaping students' academic success and career aspirations (Ogbu and Simons, 1998; Wang *et al.*, 2020).

The influence of ethnicity is, therefore, a function of the perception and experience of science for the individual. For example, some students indicated that their ethnic group does not influence their interest in science, but some mentioned that their cultures influence their interest in science. For example, a student mentioned the situation she sometimes struggles with in connection to her Romanian heritage; this is not affecting her interest in science in a negative way, but the issues such as discrimination and bias that she has faced made her more determined to study science and be successful. This illustrates the role of ethnicity in science interest in connection to challenges and how students' determination shapes their experiences. The literature supports this and concludes that the discrimination and struggles faced by ethnic minorities in STEM fields influence their determination to succeed (McGee and Bentley, 2017; Ong *et al.*, 2011).

In terms of ethnicity influences on science identity or any related themes were not mentioned specifically in science-related environments at individual level by participants in this research. However, a wealth of research has focused on minority students and their representation in science fields (Vincent-Ruz and Schunn, 2018; Rodriguez *et al.*, 2017; Atkins *et al.*, 2020; Carlone and Johnson, 2007). This is mostly because the population participating in this research was diverse, which is perhaps why students participating in the interview stated that they do not think ethnicity impacts their science identity or anything related to the conceptualised elements of science identity in the environment they have been. The outcome of research is valuable to highlight diversity importance.

Furthermore, diverse educational settings have demonstrated a reduction in discrimination and the promotion of a sense of belonging among students from a variety of groups (Bécares and Priest, 2015). This implies that diversity across educational institutions may be an essential means of developing science identities in students across ethnic and religious orientations, as in my research. The necessity for a diverse and inclusive education environment is highlighted by students, who said being in a diverse school helps them feel more relaxed and they do not feel isolated.

Also, teachers shared their thoughts by stating that there are behaviours influenced by values, but they find it important to provide an educational environment to make students more interested or maintain that interest. This is because the school setting is where students learn, develop skills and become integrated into a diverse society.

In sum, this part highlights the influence that ethnicity has on students' science identity development through their engagement with science and career plans. As discussed in this research context, ethnicity, which covers family and cultural values, and diverse school environments influence students' science identity in different ways. Therefore, support should be provided to students from minority ethnic backgrounds who may face discrimination in science fields.

5.1.5 Parents' Talks About Gender, Religion, Ethnicity, and Science

This part illustrates how the beliefs and ideas of parents relating to gender, religion, and ethnicity have informed the science identities of students. Family communications on issues related to science have expressed different viewpoints. The general attitudes of the parents, therefore, impact the relationship the children have with science. For example, in general, all students stated that their families support them in doing what they want. According to Tenenbaum and Leaper (2003), positive parental attitudes towards science significantly reinforce children's curiosity and interest. However, the outcomes of my research regarding parental influence or support in relation to science could be more closely aligned with students' personal goals. As stated by all students who participated in interviews, they receive support from their parents based on their needs or desires.

This may be because the goals of the students and their parents are consistent, or because the students are decisive about their own aspirations. For instance, despite a student's family's effort to encourage him to pursue a career in a science field by supporting him through sending him to a tuition centre, ultimately he desires a career in business. According to him, although his family wanted him to have a science-related job such as being a doctor, his family eventually agreed with his own decision.

Moreover, the role of parents' perceptions of gender in influencing students' science identities is therefore evident. For example, a student shared what she was told by her mother, which is that gender is not an issue in being successful in science, as talent and hard work are critical for success. Her supportive comment helped develop the student’s relationship with science, especially her confidence in pursuing this field. Similarly, Tai *et al.* (2006) suggested that early support and encouragement are needed for underrepresented minorities to develop their science careers. Moreover, the literature and comments provided by the teachers show that female students have recently received more support, but nevertheless, boys are afforded more attention, explanation, and support to enter science fields because, as mentioned by a teacher, Leila, a man will be responsible for the finances of the family, and the reputation of his job is important; therefore, families want their male children to have prestigious jobs. For example, according to Lee *et al.* (2020), boys have higher motivation and achievement in STEM careers compared with girls, and parents’ value beliefs are highly predictive of their sons’ science motivation and achievement.

The next part will focus on the intersectionality of gender, religion, and ethnicity, examining their combined influences on students’ science identities for a deeper understanding by discussing the findings alongside existing literature.

5.1.6 Intersectionality of Gender, Religion, Ethnicity, and Science Identity

This part of the discussion is about the complex interactions between gender, ethnicity, and religion and their impacts on the science identity of students. Because each factor is influential in a unique way on the science identity of every individual, the intersectional influences of these on science identity are likely to differ. Despite the quantitative data had limitations that interviews helped clarify the exploration of students’ science identity. These two types of data represent various preferences, interests, and feelings for science as they show science identity and its distribution across students, with more details considering gender, religion, and ethnicity.

Students addressed how gender-based norms affect their experiences, but they also mentioned that gender is not an isolated factor that is impacted by other values such as ethnicity, culture, and/or religion. Despite differences in each participant’s religious beliefs and ethnicity, gender is not the only factor that influences women; gender and religion, gender and ethnicity, gender and culture, gender and family, or a combination of gender, religion, ethnicity, culture, and family all can work together.

The experiences and thoughts shared by the students are consistent with the existing literature dealing with intersectional influences in an educational space, reflecting how gender norms, religious beliefs, and ethnic backgrounds interact with educational experiences and career aspirations (Crenshaw, 1989; Collins, 2023). For example, students stressed that the impacts of ethnicity, religion, and gender on science are complex, encompassing the conflicts and social expectations that students experience in their daily lives and in science contexts. This is similar to the findings of Avraamidou (2020) who conducted a case study of a Muslim woman's professionalism in physics; the woman experienced various difficulties and conflicts in her daily, academic, and work life because of components of her life. Nevertheless, the participants in my research had different ethnic backgrounds, and were born or raised in the UK, yet they experienced similar influences despite growing up in different environments.

Although students sometimes did not explicitly state the intersectional influences of their gender, religion and ethnicity in their science identity; however, the puzzling pieces of their interviews contribute to an understanding related to this. For instance, a female Muslim student noted that although she does not follow the Islamic dress code fully, she is still expected to cover most of her body. Moreover, her family's ethnic values supported her decision to pursue a career in science, motivated by the desire for a well-paid profession such as a doctor or dentist. Although she did not mention any negative impact of these factors on her science identity, it is possible that the positive influence of her ethnicity and culture — particularly the emphasis on pursuing a science-related career — may have overshadowed any potential challenges arising from her religion, ethnicity and gender. Ethnicity-sourced cultural interpretation of religious rules, various values, different practices, and diversity of family perceptions regarding values may allow individuals more freedom such as the Muslim female student mentioned here.

Regarding influences of the intersectionality of gender, religion and ethnicity in various ways, a student's interviews revealed an interesting perspective on how her science identity is impacted and became stronger with these influences. Although, she did not comment on these factors as a whole, again piecing together different parts of her interviews showed that she developed a strong sense of competence in science. She was the one who said 'stop it' when boys displayed gender-specific behaviours. The way of her speaking shows that she does not hesitate to react when someone's actions – whether influenced by gender, religion and ethnicity – affects someone's personal or educational life. This determination and confidence may ultimately contribute to the development of her science identity, positioning her as a strong figure in the field of science, particularly as a woman. This shows that each individual has their own way of balancing their values, aspirations, and developing their identity.

The study reveals that science identity of students are significantly influenced by parental involvement. This is in line with research on science capital, which places at its core the crucial role of parental support and encouragement in students' engagement with science (Archer *et al.*, 2013; DeWitt *et al.*, 2016b).

This research highlights the complex, intersectional nature of science identity among students. Gender, ethnicity, and religion each play significant roles, often interweaving to create unique educational experiences and challenges for students. The data underscore the importance of developing inclusive educational strategies that address these intersections to support diverse student populations in developing robust science identities (Carlone and Johnson, 2007; Hazari *et al.*, 2013). The findings on the role of a diverse school environment in fostering inclusivity contain insights similar to previous studies on multicultural education settings.

This is particularly important; during the interviews with female students, the outcomes show that factors such as their understanding of being a science person, their level of interest in science, the degree of competence compared to others, or uncertainty of career plans may lead them to think they do not have science identity. However, the details they share represent that they have science identity, or in the process of developing a science identity, even though they claim the opposite. In this context, I agree that a person is 'kind of person' as long as they identify themselves as such. However, what if their understanding, interpretation, and thoughts about qualities and characteristics of a person with a science identity do not align with the general perception and representation of what it means to have a science identity? It is worth noting that, from my perspective, when working with human participants, uncertainty is a key challenge, as it is in my research.

Overall, this study provides valuable insights into the intersectional effects of gender, ethnicity, and religion on students' science identities, highlighting that in some cases, these intersectional impacts can be positive. To achieve more accurate outcomes, various research methods, such as the mixed-methods approach, could be used. However, as seen here, this may not provide the ultimate solution. On the other hand, uncertainty is a key element of conducting new research and fosters curiosity for further inquiry.

5.2 Research Question 2: How Students Experience the Impacts of Gender, Religion, and Ethnicity on Their Science Identities Within the Obligatory and Voluntary Identity Contexts

To answer Research Question 2, which aims to understand how science identity is influenced by gender, ethnicity and religion within the obligatory and voluntary identity contexts. Obligatory identities significantly affect students' science identity, especially in terms of valuing these elements and simultaneously considering anything related to them. Religious identity was an obligatory identity for many. Religion does not limit the science identity; however, there may be some influences, as some of the teachers mentioned in their interviews, such as not preferring some career pathways because of religious rules or not being able to complete a science field trip to continue further science education.

Conversely, for example, a Muslim student emphasised that her religion encouraged individuals to be educated, so while she studies science and is successful, she also follows her religious rules. This student was the one who reminded herself religion has priority, which indicating that her religious identity was obligatory identity. The discussion about any impact of her religion on her science identity is interesting. She highlighted that her religion does not impose restrictions on whether males or females should pursue scientific fields while some other participants mentioned gender based differences among believers of that religion. Therefore, the freedom that the students had is more related to individual's culture and her family standpoint. However, this is still interesting because her religious and science identity obligatory identities. Similarly, a science teacher also mentioned in her interview that some families value being successful in the field of science, and this is independent from their religion, ethnicity or gender. This outcome is similar to that of Salehjee and Watts (2020), who found that some characteristics, which could overlap with each other, may be experienced variously, such as difficulties and/or chances to create new ways. The mentioned point here is the representation of this Muslim student's experiences.

Furthermore, individuals do not necessarily choose one belief system over another (Legare and Visala, 2011) or prioritise their religious beliefs over the importance of science (Payir *et al.*, 2020). People have various identities; however, sometimes these are not compatible with each other, and identity conflict can occur (Benet- Martínez *et al.*, 2002). This way of thinking for identity development was also stressed by students who state that they see both science and religion as important; for example, Andreea who was aware that there could be a conflict between her religion and science but she could try and reconcile both. This illustrates the struggle whereby students balance science and religion and how this process impacts their science identities. According to research by McPhetres *et al.* (2021), people can simultaneously hold both scientific and religious beliefs, indicating that religious beliefs are not always linked to negative attitudes towards science across different cultures; for example, in the case of Andreea or Amina.

Furthermore, gender and science identity development and their importance differ; for example, students who value their gender could also ignore their gender easily when they make any important decision related to science. Therefore, within this context, their science identity is an obligatory identity, especially when compared to their gender identity. In Carlone and Johnson's (2007) study on science identity, disrupted science careers were mentioned by participants; for some, this was because of their gender, which is not a unique example, as similar findings have also been reported by Eren (2021), Lock *et al.* (2013), and Jackson *et al.* (2019). Gender related issues are not strange to students because they already experience some of them. For decades, gender gaps in science have been studied, such as supporting equity and women's existence in science-related fields; numerous studies show that promoting girls' self-concept with science and their participation in science-related classes or activities by adjusting the curriculum, creating new settings, or providing role models and/or mentorship programmes helps them to overcome these gender differences (Davila Dos Santos *et al.*, 2022; Schulte and Wegner, 2021). The efforts spent on equity, equality, and diversity may help distance gender identity from being an obligatory identity due to various reasons, such as social values or expectations. These issues were mentioned by some students and teachers such as how being determined and strong was helpful for them and for people around them.

Moreover, ethnic identity is one of the significant factors influencing students' interest in science and the development of the science identity of students. The students potentially having an obligatory ethnic identity were in the majority. This is quite enlightening because when ethnicity is important for students, they may be impacted by their ethnic values more; however, during interviews, science teachers and students mentioned that the diversity of the school assists in eliminating any influences of ethnicity on science. Whilst the cultural component of ethnicity was frequently mentioned by both science teachers and students, ethnicity was the least mentioned factor.

On the other hand, when answering survey questions, students may have thought of those as values and instead indicated how important their ethnicity and science are to them. In terms of ethnicity, as an important value and being the obligatory identity of many students, it may have the most tacit and explicit influences on the science identity of students in several ways. For example, cultures, family values and expectations are elements of ethnicity, and these were mostly mentioned by teachers and students when talking about science identity and how it is impacted. For example, Asian students' willingness to work in the field of science, especially as doctors, dentists, and engineers, was mentioned by teachers; this aligns with the research of Wong (2015), which explored the science career aspirations of Black Caribbean, Pakistani, Bangladeshi, Indian, and Chinese students, hence they were mostly Asians.

This section critically interprets and discusses having a science identity, particularly when it is developed as an obligatory identity – can provide resilience and direction for students, especially those from minority or religious backgrounds. This aligns with Chen *et al.* (2020) who found that having a strong (obligatory) science identity could be advantageous for individuals who are female, from minority backgrounds, and/or have religious beliefs that conflict with science. To summarise, religion, gender, and ethnicity could be considered important elements that influence students' science identity development processes because they have junctions that are experienced and acted on accordingly by students.

5.3 Research Question 3: Science Teachers' Perspectives on the Impacts of Gender, Religion and Ethnicity on Their Science Identity and Their Students' Science Identity Through the lens of Intersectionality

This section discusses the thoughts of science teachers about being a science person and having a science identity for themselves and their students.

5.3.1 Science Teachers’ Perspective on Students’ Science Identity

The science teachers commonly described a ‘science person’ as being interested in science, being critical, using scientific methods, engaging in science-related activities, without specific characteristics such as gender, religion, ethnicity, and so on. This suggests a largely individualistic view of science identity, which, while aligning with some elements of identity frameworks in the literature, may overlook the socio-cultural dimensions that also shape how science identities are influenced.

Teachers primarily stressed the importance of interest in science because through this, students become participants in science activities, effective learners, and future science professionals. Therefore, interest in science could be the source of other elements of being a science person. This aligns with Habig and Gupta’s (2021) findings on the role of interest in sustaining persistence in science fields and long-term science identity development. This is supported by studies that demonstrated how students’ interest in and passion for science significantly influenced the orientation towards careers in science (Palmer, 2004; Jackson *et al.*, 2019). Furthermore, Owens *et al.* (2020) and Maiorca *et al.* (2021) also found that students’ engagement and interest in science could be significantly improved through practical activities and participation in science clubs or teams.

Additionally, teachers highlighted that students’ participation in extracurricular science activities could reflect their identity as science persons. Also, students’ questioning and scientific thinking, along with the ability to be analytical, are characteristics necessary for students to become science persons. According to Kuhn (2005), analytical thinking capacities are engaged in developing and practising scientific knowledge. This is a significant point highlighted by teachers, an individual who is a science person not only knows scientific information, but also is able to use such information by adopting it into daily life.

As the teachers stated, students’ confidence in science-related subjects is a necessary condition for them to become a ‘science person’. Confidence in science makes students more willing to apply knowledge and skills in science. Bandura (1997) found that self-efficacy positively influences academic success and the orientation of students to scientific careers. Furthermore, internalised resilience, which could be described as determination and confidence, has been reported as relating to positive outcomes in science among students by Duckworth *et al.* (2007) and Datu *et al.* (2018).

For teachers, students' success in science is an essential indicator of the way they become a science person. Such success encompasses not only the academic but also the general attitudes of students towards science, as well as the cognitive abilities and skills of problem-solving. The impact of success on being motivated to study science could be a key element, as many students in the interviews mentioned that they have less interest in physics because they think it is difficult. Despite some still show confidence but when there is a lack of confidence in physics student tends to show less interest, as shown in the research findings. Furthermore, an interviewed science teacher underlined that the development of a strong science identity is paramount for successful science outcomes to be realised. This was also captured in a phrase for 'moment of success'. This perspective aligns with studies showing that strong science identities contribute to positive outcomes and aspirations in science fields (Carlone and Johnson, 2007; Archer et al., 2014; Tytler, 2014).

Moreover, scholars have examined the factors that impact the science career plans of students who are from different ethnic backgrounds, supporting the importance of diversity in the concept of being a science person (Carpi *et al.*, 2016; Tytler, 2014; Garcia *et al.*, 2024). My research also highlighted the importance of raising awareness about the diversity of science persons and promoting equity and equality in science education.

While science teachers did not specifically address identification and recognition as a science person as a formal construct, they did refer some students as science persons and this is implicit act of recognition. This supports Carlone and Johnson's model, though recognition as a science person as an important component of science identity. Furthermore, interest is the most frequently mentioned quality of being science person while competence in science is referred to by teachers many times as being successful in science and being able to show scientific abilities such as actively participating, asking questions, and engaging in discussion. In conclusion, the characteristics mentioned by teachers related to being a science person, which represent having science identity, are accurate and consistent with this research's conceptualisation of having science identity in the literature review chapter – science interest, science competence, science career plan and identification and recognition with science.

5.3.2 Teachers' Experiences with Gender Related Impacts on Students' Science Identity

The science teachers shared their views and experiences related to gender and science identity, which are discussed in this part within the main highlights. Whilst some teachers thought that gender does not have any effect on the science and the science identity of students, others argued that it does have an impact.

According to some teachers, the outcomes of gender influences are not restricted to science identity; it has various impacts in educational settings. The reason is that when talking about gender, participants mentioned various instances that are shaped by their different values, such as ethnicity and religion. For example, the misogynist behaviours of some students towards female teachers were stressed by teachers; additionally, some students may not show the same level of respect to female teachers and female science teachers as science is associated with power, intellect and authority.

However, the mentioned misogynistic behaviours of students toward female science teachers, as highlighted in the literature review, are the overlapping influences of misogyny and patriarchy. Even the age or authority of teachers may not shield them from such behaviours, when gender is involved. For instance, the research conducted by Skelton *et al.* (2009) with younger students in the UK addressed the stereotypical gender perspectives used to describe their teachers; boys described their teachers in terms of authority, knowledge and humour, while girls recognised their female teachers as kind, caring or possessing other feminine characteristics. However, girls in Skelton *et al.*'s (2009) research also described both male and female teachers using neutral or masculine characteristics. These viewpoints suggest that, to some extent, being a teacher is associated with authority, which is linked to masculinity and power due to stereotypical gendered understandings. As a result, female teachers may be masculinised when they are described as authoritative roles, even though they are simultaneously represent feminine qualities.

The authority of a science teacher was mentioned by teachers in various ways. For example, one teacher shared her experiences about being challenged by students because they would like to see her competence in science, whilst another teacher mentioned how being head of science and science teacher makes a difference to students' gender-based behaviours. Nevertheless, as addressed by another teacher, being a female science teacher gives some authority to female science teachers. This also aligned with Clark Blickenstaff (2005), the feeling of authority in female teachers can be manipulated by gender roles and prejudices. Therefore, while being challenged by students is one side of being a female science teacher, while being seen as a science authority as a female teacher is another side. This could be related to science-masculinity-power association; however, my research revealed that the emphasised precautions regarding diversity and equality, and strong personality of science teachers were there to deal with these gender-based stereotypes.

Teachers expressed various thoughts related to gender and being a science person; for instance, female students perform better and tend to study science more, but they do not study physics at A-level. This is consistent with other research studies which show that female students score better in biology and chemistry whereas male students perform better in physics (Steele, 1997; UNESCO, 2017). However, the underrepresentation of females in the physics and engineering fields is almost always linked to gender bias and stereotypes (Hill *et al.*, 2010; Eren, 2021; Lock *et al.*, 2013).

Although some studies have revealed that girls' inequities and social expectations influence women's representation in science and engineering (UNESCO, 2017; Shirazi, 2017), such expectations can be seen as depending on the argument that boys are already perceived as successful when taking exams, which is a reflection of persistent gender differences in academic performance. On the other hand, as noted by Hadjar *et al.* (2014), gender differences have been reduced, but there are still some barriers between women, and some subjects for studying and career options. This might be an important point to address because the interest in a certain career is decisive in students' choice of A level subjects and can significantly influence the continuum of development of science identity. This is highlighted by teachers and students in my research.

Moreover, teachers stated that there are no gender differences among students who have a science interest, but there are various specific interests in science subjects of by gender. For example, female students are interested in chemistry and biology, which is mainly due to family and social factors because female students are encouraged to have jobs that are related to caring, or at least jobs that let women accomplish their responsibilities at home. In short, the specific science interest in biology or chemistry could come from social expectations. This was also addressed by Eccles *et al.* (1990); in their expectancy-value theory, they asserted that the family and social surroundings provide the formations of interests for students. This is also discussed in the literature review chapter, focusing on how individuals grow up and live with their social values (Kakavoulis, 2001; Tekke *et al.*, 2020; Mills *et al.*, 2012); therefore, students' career plans can often be observed early during high school as they begin deciding what to study. As a result and as mentioned previously, inequities and social expectations for females impact their presence in science and engineering fields (UNESCO, 2017).

However, in terms of expectations of family, the support, especially from parents, could change the social expectations that impact students and form positive role models that contribute to their interest in science (Luo *et al.*, 2022; Wang *et al.*, 2023). This is a common point in my research findings; teachers stress that as long as female students are supported by their families, they tend to choose more science fields.

On the other hand, there are some students who do not take support into consideration and do what they want because of their high level of science identity. However, the difference with these female students is that teachers describe them as 'strong girls', which means their personality and drive to persist in the field of science is stronger than others, but the issue is that unfairness is effective on those who are not strong enough. In other words, while the phrase 'strong girls' as used positively by teachers, it may implicitly reflect that only those with an obligatory science identity could overcome systemic gender barriers in science.

The competence of students could be related to feeling comfortable in an environment, their academic success, such as understanding the topic, their specific interest, or other factors. For example, in the study conducted by Dost (2024) on students' perspectives about belonging in the STEM field, being secure and comfortable in the community and setting was one of the most frequently mentioned criteria among participants. From these points, multiple factors — such as feeling a sense of belonging, being safe, comfortable, skilled, and successful — could influence students' competence; additionally, their gender would lie another dimension, such as misogynistic and stereotyped behaviours toward female students, like being told to 'go to kitchen'. Fortunately, female students develop a defence system, at least to some extent, to deal with these kinds of behaviours. However, even in secondary school educational settings, boys can label girls' place as the kitchen instead of being busy with science learning, and girls need to be as confident as boys to be persistent in science when they are in such environments.

Teachers mentioned that having many female science teachers is encouraging for female students as it shows them women could study science; this is supported by the study of Chen *et al.* (2020) which found that female science teachers could positively influence female students to study science.

To summarise, all these dimensions of the role and influence of gender in science and educational contexts are supported by academic literature; however, the specific context of this research provides important details into students' science identity development and the influence of gender within it. The basis of interest and confidence lies in gender roles, bias, and cultural aspects on one side, and all these factors result in the inclination towards a particular career choice for the student. As such, the policies, strategies, and practices in educational settings for science should be designed to support gender equality. Intervention should be aimed at handling biases based on gender and offering equal chances or giving freedom and opportunity within the science education to promote environments that are more inclusive in the STEM fields (UNESCO, 2017), especially for people who may develop a science identity.

To conclude, gender is a multilayered variable, which, almost certainly, one way or another, impacts the overall experience of science teaching as well as students' science identity development, sometimes for the worse and sometimes for the better.

5.3.3 Teachers' Thoughts Related to Religion Impacts on Students' Science Identity

This part of discussion focused on how religion impacts students' science identity. However, the way teachers handle their religious beliefs when teaching scientific knowledge is also discussed because this may affect teachers' professional attitudes and the learning experiences of their students. For example, teachers demonstrate a professional negotiation between belief and pedagogy; therefore, teachers also underscore the fact that they do not intend to be judgmental or dismissive of students' beliefs when teaching theories such as evolution. These findings are consistent with the literature on how teachers in scientific education attempt to be simultaneously objective and tolerant in science education (Hermann, 2013). For instance, Neha emphasised the distinctions she made between religion and science, and also emphasised that the layers of influence exerted by religion on students' science identity are complex. Emily, in contrast, claimed that priority should be given to students' questioning and learning systematic information, rather than to beliefs. The encouragement for questioning will allow students to develop better critical thinking skills for understanding and learning scientific knowledge more effectively (Syarifuddin, 2018).

Ecklund and Scheitle (2017) highlighted the complexity of features and individual differences in the process of developing religious beliefs, regarding students' science-related careers. Some teachers avoided drawing a causal link between religion and science identity, however they mentioned that the perspectives or adoption of religious rules vary among the students they teach, even if some of them believe in the same religion. In other words, some issues in the classroom when learning certain topics, such as evolution or the menstrual cycle could be influenced by students' religions, but the problems are more related to society and culture. This finding reflects the complexity of the interplay between religious and ethnic factors in scientific learning, as well as the effects of these same dynamics on teaching practice (Dagher and Boujaoude, 2005).

The discussion about the conflict between religion and science provided more details about that teachers described the classroom as a space where religious worldviews and scientific explanations may occasionally clash because if their believed religions are not aligned with evolution theory, the classroom is the most likely place for students to learn about it. Teachers highlighted the sensitivity surrounding the theory of evolution, and its learning and teaching process. This sensitivity may be more related to students' feelings, which could make students think that learning about evolution implies accepting it and, in turn, abandoning their religious beliefs. This aligns with literature, Barnes and Brownell (2016) who stated that when students are required to learn evolution, they may think that their belief system will be changed by educators, and therefore their interest in learning these topics could decline.

While such tensions risk undermining students' trust in science, teachers reported using inclusive strategies to mitigate these effects. Rather than confronting religious beliefs directly, teachers stressed the importance of respecting students' backgrounds while highlighting the importance of learning the science curriculum. For instance, several teachers mentioned that students may show a tendency to reject scientific knowledge because of the opposition to their religion, resulting in decreasing success in science, or students distancing from science. As investigated by O'Brien and Noy (2018) and Noy and O'Brien (2018), students from religious backgrounds tend to experience uncertainty when faced with scientific ideas that are at odds with their faith, and this acts as a catalyst for their distancing from scientific beliefs and may serve as a discouragement to have science-related careers. In such cases, educators should understand and respect religious beliefs whilst promoting scientific thought, as the participating science teachers do. The conducted research by Longest and Smith (2019) underscores the need for educators to be sensitive in bridging the gap between religious beliefs and scientific understanding.

Sometimes, religious students may show great interest and achievement in science if the educational environment supports them and is inclusive (Taber, 2017; Mayrl and Oeur, 2009). Additionally, the participating science teachers summarised these research outcomes related to the conflict between science and religion by emphasising the importance of creating an inclusive and comfortable environment that allows students to question, learn, and make their own decisions. This approach is similar to the research conducted by Yasri and Mancy (2016) in Thailand, which focused on providing students with opportunities for better understanding of the evolution.

Another theme of science identity is competence in science and how religion influences competence in science. Also, there might exist science or science-field-related doubts in highly religious individuals (Ecklund and Scheitle, 2017); however, a very supportive family environment may change this, making them more confident in science (George, 2006). For example, my research also reveals that parental attitudes and social environment are key factors in influencing students' confidence in science. As highlighted by Gondwe and Longnecker (2015), the positionality of family and their cultural interpretation related to religious rules can vary and differently effect students. For example, one of the interviewed female students shared her worries about being excluded in the field of science because of her faith; however, the exemplified case also provides an informative point because the support provided by her family encourages her by helping her to become more familiar with the science field environments.

Teachers recognised religion as not the sole influence on students' career plans, but interpretations and practices of religion, according to different ethnic values, could affect students' career plans, especially when other factors, such as gender, are included. As some science teachers explained, students who are religious may face implicit or explicit guidance about which careers are considered acceptable by their religion, however, the religious doctrine or application could vary across ethnic groups. Nevertheless, the doctrines/rules/application of religions are not absolute, they differ across families, ethnicities, including cultures. For example, families may temporarily set aside religious or ethnic prescriptions in favour of socially prestigious careers, such as medicine. These results align with those of Bryant and Astin (2008), they highlighted that religions affect the career options of people, as well as the family and cultural policies that govern such decisions. The effects of religion were mentioned by teachers.

To conclude, this research investigated science teachers' various opinions on the relationships between religion and science. This research reveals that trying to achieve a balance between objectivity and tolerance in science-accepted facts is what enables the student to think critically and improve their learning and understanding of these facts. In addition, teachers stated that to understand the complex effects of religious and cultural values on students' scientific interests, confidence, and career plans, teaching strategies are essential and need to be appropriate for situations. As stressed in my research, people believe in different religions at different levels or do not believe any religion, but everyone has the right to decide what they believe; therefore, teachers' responsibility is creating a non-judgemental learning environment.

5.3.4 Ethnicity including Cultural Values Influences in Science Identity

The effects of ethnicity on science teaching and students' science identity are discussed in this section with supporting findings from the literature. Some teachers viewed ethnicity as neutral in science and teaching science. Even though there may be no impact of ethnicity on becoming or being science teachers; however, being science teachers with various ethnic backgrounds is important for students, especially for those who are minority in the field of science. The importance of being a role model was highlighted by Sleeter and Carmona (2017), as well as participated science teachers did.

Teachers discussed science identity and its conceptualised elements explicitly with influences of cultures and families. However, cultural values are demonstrated under ethnic influences because of the focused elements in this research and how they are conceptualised. Moreover, the influence of ethnicity on students' science identity varies across different dimensions — such as their interest in science, academic success, and career aspirations — these may be shaped, to some extent, by family expectations. The broad concept of ethnicity may have implicit impacts as mentioned by teachers. For example, such opinions match the expectancy-value theory propounded by Wigfield and Eccles (2002), according to which interest in some fields by individuals is extensively guided or influenced by their expectancy of doing well in these fields and their attachment to those fields. For example, Johan claimed that parents influence Indian students' interest in science, whilst Emily stated that Somali students can succeed better in science. Additionally, Leila claimed that ethnicity and culture have effects on students' interest in science, but equality of opportunity and previous experiences cannot be ignored.

The impacts of ethnicity on career plans, especially science career plans, are a popular topic in science education literature. In this study, the participating teachers shared their experiences and thoughts, stating that ethnically-sourced expectations that direct Asian students toward some science career which are prestigious for them or their families. These findings are supported by studies conducted by Sue and Sue (2016) and Lee (2009), who noted that the families of certain ethnic groups, such as Asian and Asian American, encourage their children to enter more prestigious professions according to their values which come from ethnicity or culture, affecting the scientific careers of students. In essence, the effect of ethnicity and culture on science career plans could shape the motivation and interests of students in relation to science, as some of participating science teachers highlighted.

In terms of the relationship between ethnicity and confidence in science, teachers mentioned an intriguing point which is related to language and accent. As the part of ethnicity, language can affect students' self-confidence in science. These results align with those of Steele (1997), a study that was not recent but is strongly related to the focus of this part; if ethnic individuals are subjected to prejudiced environments, either based on their ethnic identity or accent, their actions and self-efficacy can be negatively affected. This is interesting because the school where the research was conducted is diverse in terms of the ethnic backgrounds of students. Therefore, even as a member of a minority group, a student can still feel different, even when the majority of people around them are part of various minority groups.

To conclude, teachers' experiences and the academic literature show that ethnicity is essential to the development science identity process; it affects various matters such as role modelling, developing interest and confidence, and career planning.

5.3.5 Teachers' Perceptions Regarding Intersectional Influences of Gender, Religion, and Ethnicity in Students' Science Identities

The influences of gender and ethnicity are quite significant within the scientific contexts. Additionally, when piecing together factors related to these influences, the process becomes more complex due to gradual experiences of individuals in various situations. The reason for highlighting the relationship between gender and science-related interest and success is that there is no clear distinction or formula for how gender influences an individual's interest and success in science, especially during the science identity development process, as gender is not an isolated factor. For example, in my research, the teachers who specialised in physics emphasised that female students do as well in physics as other subjects, but so far, they do not tend to choose this pathway to study. This may be due to lack of competence in physics or science but a lack of interest in physics or science, or it may be that physics is not part of their intended career plans.

The influences of ethnicity, and gender are varied due to subcultures, family type, and students' — especially female students' — desires and career plans. Although gender impacts on interest and motivation, the findings in this research reveal that for some ethnic groups, science is important, especially to pursue careers such as doctors, dentists regardless of their gender; therefore, female students are supported to do well in science and motivated to be in these fields. However, if the ethnic background and family do not celebrate success or value having a job in the science field, gender and being from an ethnic minority will work together in a negative manner as highlighted by teachers in my research. Therefore, while many scholars focused on the disadvantages of gender stereotypes or ethnic influences in science-related contexts, the intersectionality of gender and ethnicity within a family context that values science and science-related jobs can work together to create advantages through support.

Moreover, when piecing together the interviews with students and teachers, according to some ethnicity related perspectives, women's places in the professional world are preferred to be related to or allow individuals to fulfil caring and nurturing demands. While these expected roles depend on cultures and individuals' upbringing, social and professional environments may not allow individuals to pursue the careers they desire equally, especially when certain cultural responsibilities are placed on them. For example, the concept of 'academic housework' mentioned by Heijstra et al. (2017) and Read (2024) is relevant here, to some extent. 'Academic housework' refers to responsibilities within academia that are not directly contributing to research or knowledge creation. While these tasks are essential in the academic environment, they receive little recognition for career advancement. The term 'academic housework', used by scholars, may be a significant point in illustrating how lower-ranked researchers are influenced by systemic issues. Although this concept is not the central focus of my research, it highlights how systemic, cultural, or ethnic issues impact female students, particularly those with certain ethnic backgrounds and cultural codes, in their career plans.

For example, as mentioned earlier, female individuals may shape their career plans according to their ethnic norms. As a result, they may pursue careers such as nursing, science teaching, health sciences, pharmacy, or medical/laboratory works. In this context, these could be described as 'scientific housework'. This term is not considered lower-status service roles, requiring less autonomy and fewer resources compared to fields like engineering, medicine, or dentistry. The contribution of ethnicity and gender to systemic issues such as the leaky pipeline and glass ceiling should be highlighted, and this part of the research provides a nuanced and insightful perspective on these issues through the intersectional lens by focusing on how ethnicity and gender influence female students' career plans - whether in science or not.

Another important point, as already discussed, is the influence of religion mentioned by teachers. However, the intersectional influences of religion and gender are different from the influences of a single element. For example, if a boy would like to pursue a job which may not be compatible with his faith, he may still be encouraged to pursue that job because of the culturally attributed responsibility of being a breadwinner. This is supported by the research of Riegle-Crumb *et al.* (2011) which highlighted the limitation on the freedom of students belonging to specific ethnic groups imposed by their family or society members, decreasing their level of attraction to science and inhibit their performance in the respective field.

Another example of the intersection of religion and gender was provided by a teacher about his experiences regarding some parents of Muslim female students who either do not allow their daughters or hesitant to allow them to participate in overnight field trips, which are necessary for completing some science exams. The teacher had never observed Muslim male students' families being hesitant to provide consent for their sons' overnight field trips.

This intersectional influence of gender and religion has broader impacts on female students' educational progress and, potentially, their career plans. On the other hand, not all Muslim families restrict their daughters. This variation may be related to level of religiosity, as well as cultural flexibility or differing interpretations and practices of religious rules. Additionally, this may reflect the value that families attribute to science. This points to how the intersectionality of gender and religion can restrict students, whereas the intersectionality of culture and science can support them. In this context, this could be an indicative case for gender, religion, and ethnicity are main and interwoven elements that impact students' engagement with science and their development of a science identity.

These educational inequalities related to science are heavily influenced by this complex interaction of factors around gender, religion, and ethnicity. Possible solutions to the aforementioned issues include ensuring that the education system is more inclusive and equitable, and that an understanding of inclusivity and equity is taught. Educators should, therefore, take such trends into consideration in order not to leave students out and thus support them in developing scientific thinking skills. Teachers, even students, are aware of these circumstances and are making significant efforts to deal with them. It is, therefore, imperative that the educational policies and curricula developed and implemented should be tailored to suit the needs of the diverse group of learners.

6 Chapter 6: Conclusion

In this research, the main aims were to understand the impacts of students' gender, religion, and ethnicity on their science identities by adopting the lens of intersectionality; to examine the students' adaptation and positionality in relation to their gender, religion, ethnicity, and science identities from the perspective of obligatory and voluntary identities; and to explore teachers' views about having a science identity for students and how it is impacted by gender, religion, and ethnicity.

Science identity is conceptualised as having science interest, identification as and recognition as a science person, competence in science, and having a career plan in a science-related field. Another theoretical concept to highlight is voluntary and obligatory identities which help understand how individuals prioritise and navigate their identities in various contexts. Regarding methods and methodology, the study was designed as a mixed-methods approach to collect both qualitative and quantitative data from participants. The constructivist paradigm is adopted to interpret situations and understand phenomena that are built socially. Therefore, individuals' uniqueness was valued in the research in order to explore and understand their thoughts and related experiences.

This research revealed that being a science person could be the first step towards developing a science identity overall, based on the interpretations of participants in the way they speak about having science identity. While gender biases may discourage female students from pursuing male-dominated careers, on the other hand, the influence of ethnicity in gender-science context could be positive, or at least neutral, regarding attributed importance to science which makes females supported. In my research, one of the most outstanding outcomes could be awareness of and trust in global changes in social dynamics, especially for women regarding equality in science fields, as mentioned by teachers and female students.

Several students mentioned that there is no direct influence of ethnicity on science identity; many stated that they find their ethnicity important when deciding upon their career, as well as their parents being effective; the career decision in science is a component of having a science identity and is also part of the construction of science identity with interactions between various science-related feelings and motivations such as acceptance, confidence, enjoying, and so on. In school setting, any ethnicity impacts have not been experienced by students because they all thought that they may not feel like a minority in their school because of immigrant diversity.

In terms of the impacts of religions, the concrete influences are related to teaching and learning controversial topics such as evolution, experiencing limitations placed by some families on students' attendance in science field trips, and religious rules forbidding individuals to have some sort of career. In terms of the differences among gender-based career stereotypes in Muslim communities, my research showed that the application of religion in life is driven by the interpretation of people and their cultural differences while religion's rules are the same for everyone.

The voluntary and obligatory identity frameworks provide a new perspective for adopting and interpreting powerful identities through the lens of intersectionality, because these values are not ignored. Especially, when conflict occurs where the obligatory identities of individuals intersect, they may experience more powerful influences.

Moreover, many participants did not report any direct impact of ethnicity or religion individually; however, those who embodied multiple minority identities—such as being female, Muslim, and from a minoritised ethnic background—faced nuanced pressures as well as advantages that could not be fully understood through a single-axis lens. This complexity highlights that identity is not stable but multiple and interactive, often creating spaces of resilience. The intersectional lens highlighted absences in representation, such as the absence of Black Muslim female students with science identities. Highlighting the negative experiences participants faced such as gender bias, misogynist behaviours, religious conflicts with science, and underrepresentation of some ethnic backgrounds, and stressing advantages such as ethnicities valuing science and success, or required to be educated as Muslim, the intersectionality in this study was not only a lens but a critical perspective for making visible the subtleties on the science identity development process. In summary, while gender, religion, and ethnicity each influence students' science identities in various ways, this research shows that their interweaving creates more complex dynamics than any single factor alone. Therefore, the intersectional lens was essential in uncovering the complexity of gender, religion and ethnicity influences on students' science identity development.

6.1 Contributions to Knowledge

This research aims to contribute to the science identity literature by exploring what science identity is and the influences of gender, religion, and ethnicity through the lens of intersectionality. There are dominant models of science identity such as Carlone and Johnson's (2007); however, there is no unified or definitive understanding of science identity, nor a comprehensive understanding focusing on influences of gender, religion and ethnicity, especially for students at an early age in developing a science identity. While many studies on science identity development focus on individual identity categories (e.g., race, gender, ethnicity, or religion), relatively few adopt the intersectional perspective that considers how these factors interact. My research addresses this gap by focusing specifically on the intersections of gender, religion, and ethnicity, critically aligning with and extending the work of Salehjee and Watts (2023), who examine the science identity of British South Asian women through the intersectional lens.

The powerful illustration by Salehjee and Watts, using a narrative-based study, provides a detailed understanding and exploration of the science identity of South Asian women in various contexts, such as formal education and wider sociocultural settings. Their work emphasises the interactions of identity, agency, family, and cultural influences — including family culture and hybrid cultural engagement — as well as ethnicity, religion, gender, immigration and systematic barriers. Similar to their approach, science identity in my research is also non-linear, unstable, and multiple.

Moreover, my research extends the study of Salehjee and Watts by investigating students' and teachers' perspectives on science identity, and how students' science identity is influenced by gender, religion, and ethnicity through the intersectional lens. It also encompasses the concept of voluntary and obligatory identities. The participants in my study differ in that they represent a range of genders, ethnic backgrounds, and religious beliefs. Furthermore, my research specifically focuses on understanding younger students' developing science identities in secondary school settings, revealing how identity is still under construction and more vulnerable to shifts influenced by peers, family, and teachers. Salehjee and Watts' findings, such as the importance of South Asian family support, and successful co-navigation of faith and science despite conflicts between them, are reflected in my research, though with some variation.

My study provides an inclusive perspective for understanding the complexities of positive influences to some extent. For example, the participants provided valuable information about their experiences regarding navigating challenges to develop coping strategies and seeking support from their family, teachers and peers. Notably, this research examines how young female students challenge gender-based stereotypes in science, how religious beliefs influence students' views on scientific concepts such as evolution, and how ethnic minority students create invisible spaces for themselves in their current science education context and in future science-related contexts. Another key contribution of my study is the exploration of the experiences of invisible minority individuals; the participants are primarily from ethnic minority backgrounds. The concept of ethnicity encompasses cultural and familial values which impact the development of science identity, sometimes in a negative way such as reinforced gender stereotypes. However, the advantageous influence of ethnicity is family support, similar to the highlighted point made by Salehjee and Watts (2023).

Teachers offer valuable insights as first-hand witnesses to students' science identity development, serving as information sources, science authorities, and role models. As research was conducted, both students and teachers mentioned that the majority of students do not get any extra support apart from their science lessons at school. Despite the lack of extra sources, teachers strive to provide an enhanced, diverse and beneficial educational environment for students. As stressed by teachers, as long as students have talent and aspire to pursue science, they should receive education and participate in scientific fields regardless of any challenges they face, their social or spiritual beliefs, or their social environments.

Ultimately, the key commonality between Salehjee and Watts' study and mine is the adoption of the lens of intersectionality. While they focus on a personal, micro-level lens that helps to understand individuals' experiences, uniqueness and layered identities, my research shares this intersectional lens approach but applies it to a different population with varied gender, religious and ethnic backgrounds. My research also draws on Crenshaw's approach to intersectionality, which is a sociologically broad framework. In addition, it incorporates the perspective of Else-Quest and Hyde (2018), which is transformative foundation. By examining the intersections of gender, religion and ethnicity in an ethnically and religiously diverse mixed-gender school setting, the study offers a deeper understanding of how these elements influence students' experiences and engagement with science in relation to developing a science identity.

6.2 Implications for Practice and Policy

Based on the findings and contributions to the knowledge of this research, several key recommendations can be made for educators, policymakers, and researchers to better support students' science identity development and the science education process for students.

For educators, it is crucial to create inclusive and supportive science learning environments by integrating intersectional approaches in science education. Teachers should recognise and address the intersectional influences of gender, religion and ethnicity on school students' engagement with science and their positionality in relation to science identity development. This could be managed through the inclusion of diverse role models and narratives to ensure individuals can see themselves represented in the fields of science. Increasing the visibility of female science figures, not just scientists, could be helpful in promoting the visibility of women to challenge gender-based stereotypes, especially in the fields of science.

Another key point in science education is that the conflict between religion and science is most often experienced through the learning certain scientific topics. However, discussing the interface or conflicts between science and religion is important, particularly in controversial areas such as evolution and creationism. This approach is supported by Rankey (2003), who found that engaging students with opposing viewpoints in the context of evolution promoted critical thinking abilities. Furthermore, as my research highlights, factors such as age group, demographics, educational environment, discussion style, and the treatment of students with religious beliefs are all critical in shaping effective discussion environments. Therefore, these factors must be carefully considered to prevent negative dispositions. Building on existing studies and my own findings, I argue that incorporating discussions about the social and cultural components of science, such as religious views and theories in science, may improve the general understanding of scientific research and promote a more inclusive learning environment.

Regarding policies, specific challenges faced by students from various ethnic and religious backgrounds should be addressed by authorities. Moreover, teacher training on diversity and inclusion should be expanded through professional development. Due to globalisation, educational settings often lack clear majority group; therefore, individuals should be prepared to navigate increasingly diverse environments in the future. In addition, some programmes could be arranged by educational institutions to provide informative sessions for parents to highlight the importance of science education, significance of parental support for their children, and include parents in educational development. Programmes for teachers and parents, specifically designed for these purposes, could be helpful to provide more effective support for a diverse student population, especially those who need it. Moreover, funding and support can be strengthened to ensure equality for students who are underrepresented in science fields; and this may reduce the influence of barriers.

In terms of recommendation to policymakers in Türkiye, particularly Ministry of Education, which is sponsor of this research, this research provides valuable insights into understanding the importance of diversity . Policymaker in Türkiye should consider the crucial needs for the challenges faced by students from ethnic and religious minority groups because the majority of population is Turkish and Muslim; however, the minority groups in Türkiye should not be overlooked.

For researchers, there is a need to expand intersectional studies on science identity to gain deeper understanding of the factors that may influence science identity development. For further research, a relatively larger number of participants in interviews could be recruited to examine science identity and how it is influenced by religion, gender, and ethnicity through the lens of intersectionality. Also, creating a purposive sample of individuals who specifically experience the intersection of these and have a science identity could be useful for discovering more detailed information. In addition to methodological adjustments, longitudinal studies would be useful for investigating science identity development processes while taking the influences of gender, religion, and ethnicity into account. Also, including students’ parents in future research would provide an additional perspective on the topic, while also offering a deeper understanding of the different values that influence science identity, and how and why these values are influential. To expand research outcomes into a new field, it would be intriguing and instructive to investigate in depth the psychological defence mechanisms and social acceptance of individuals who experience the negative influences of social values on their science identity development.

6.3 Final Reflection and Closing Statement

This research explored the complex influences of gender, religion and ethnicity on school students' science identity by applying the intersectional lens. My research contributed to a deeper understanding of the challenges and opportunities faced by students with various values and diverse backgrounds.

Despite the challenges, such as participant availability and time constraints, the process reinforced the importance of including diverse voices in educational studies. The research also underlined the need for more inclusive approaches in science contexts, especially in educational settings, to ensure that all individuals feel a sense of belonging in the field of science. Therefore, conducting the research has been both intellectually rewarding and personally enlightening.

As highlighted, the study provided a valuable contribution to the science identity literature. However, it also raises further questions, such as how additional factors – including socioeconomic status and cultural expectations- influence the science identity of individuals, and whether longitudinal studies could offer insights into how science identity change over time. By continuing to investigate these issues, fairer, more accessible, and more inclusive educational environments and science spaces could be created.

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8 Appendices:

8.1 Appendix 1: Ethics Approval

College of Business, Arts and Social Sciences Research Ethics Committee
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.uk

18 February 2022

LETTER OF CONDITIONAL APPROVAL

APPROVAL HAS BEEN GRANTED FOR THIS STUDY TO BE CARRIED OUT BETWEEN 18/02/2022 AND 30/09/2024

Applicant (s): Miss Gamze BILEN

Project Title: How Religion, Gender and Ethnic/Race Identities Influence the Science Identity of Students Through the Lens of Intersectionality?

Reference: 31327-MHR-Feb/2022- 37886-2

Dear Miss Gamze BILEN

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- **C2 – Questionnaire – modify/delete the age category on your online consent form according to the needs of your study.**
- **You are not required to resubmit your BREO form after making the change listed above.**
- **The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.**
- **Please ensure that you monitor and adhere to all up-to-date local and national Government health advice for the duration of your project.**

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.
- Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.
- The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study.
- If your project has been approved to run for a duration longer than 12 months, you will be required to submit an annual progress report to the Research Ethics Committee. You will be contacted about submission of this report before it becomes due.
- You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor David Gallear

Chair of the College of Business, Arts and Social Sciences Research Ethics Committee

Brunel University London

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8.2 Appendix 2: Students Questionnaire

Researcher's Name and Contact Detail: Gamze BILEN gamze.bilen@brunel.ac.uk

This questionnaire aims to investigate students' attitudes towards science, science education and their science-based career plan (if they have). The purpose of the questionnaire is to collect data from participants as a first phase of the research to answer the research questions of the designed research about science identity. The second phase of the data collection is based on interviews. Your answer on this questionnaire will help me to complete my PhD research in science education and to bring in a resource to literature.

The following table is to get your consent for your participation in an anonymous online survey/questionnaire. Please confirm the following:

1. What is your gender?
    - Male
    - Female
    - Non-binary
    - Rather not say
2. Have you ever been expected behave in a certain way based on your gender?
    - Yes
    - No
3. Have your parents ever talked about your gender and its impact your life?
    - Yes
    - No
4. Have your parents ever discussed with you about your gender and its potential impact on your career plan in the future?
    - Yes
    - No

5. To what degree do you believe your gender influences your decision-making about your future job path?
    - Great deal influence
    - Some influence
    - Little influence
    - No influence at all
    - Not sure
6. Were you born in England?
    - Yes (If you say yes, please go to Question 9)
    - No
7. For how long have you been living in England?

    …………………………………………
8. How would you describe your ethnic group?
    - White, or
    - Mixed/Multiple ethnic groups, or
    - Asian/Asian British, or
    - Black/African/Caribbean/Black British, or
    - Chinese, or
    - Arab, or
    - Other ethnic group Please Specify ………………………….
9. What is your native language or the language you grew up speaking?

    ……………………………………………………………………
10. How important your ethnicity for you?
    - Extremely important
    - Important

- Moderately important
- Not very important
- Not important

11. Do your parents talk to you about your ethnic background?
    - Yes
    - No (If you say no, please go to Question 15)
12. Do your parents talk to you about your traditional values?
    - Yes
    - No
13. Have your parents ever discussed with you about your ethnicity and its effect in your life?
    - Yes
    - No
14. Have your parents ever discussed with you about your ethnicity related to your career plan in future?
    - Yes
    - No
15. What do you think to what extent your ethnicity has an influence on your decision making about your future career plan?
    - Great deal influence
    - Some influence
    - Little influence
    - No influence at all
    - Not sure
16. What is your religion, even if you are not currently practising?
    - No religion (If you choose 'no religion', please go to Question 21)

- Buddhist
- Christian (including Church of England, Catholic, Protestant and all other Christian denominations)
- Hindu
- Jewish
- Muslim
- Sikh
- Other religion

  Please specify …………………………………

17. How important your religion for you?
    - Extremely important
    - Important
    - Moderately important
    - Not very important
    - Not important
18. Do your parents talk to you about your religion?
    - Yes
    - No (if no, please go to Question 21)
19. Have your parents ever discussed with you your religion and its approach toward your educational life?
    - Yes
    - No
20. What do you think to what extent your religious preferences have an influence on your decision making about your future career plan?
    - Great deal influence
    - Some influence

- Little influence
- No influence at all
- Not sure

Could you please state that how much you agree with the following statements?

		Totally Agree	Agree	Not sure	Disagree	Totally Disagree
	I am interested in science.					
	After an interesting science activity is over, I look for more information about it.					
	Knowing science helps me understand how the world works.					
	I often go or attend to an after-school science club and/or activity.					
	I like reading books which are related to science.					
	I like watching videos and/or TV shows which are related to science.					

Could you please state that how much you agree with the following statements?

		Totally Agree	Agree	Not sure	Disagree	Totally Disagree
	In science activities, I believe I have done well.					
	I feel like I belong in the area of science.					
	I think I am a science kind of person.					
	My family thinks of me as a science person.					
	My friends think of me as a science person.					
	My teachers think of me as a science person.					
	I think I am a science person but I don't want to be known as science person by others.					

Could you please state that how much you agree with the following statements?

		Totally Agree	Agree	Not sure	Disagree	Totally Disagree

	I would like to have job that uses science.					
	A science qualification can help you get many different types of job.					
	I would like to have job that does not use science.					
	Knowing science helps me understand how the world works.					

Could you please state that how much you agree with the following statements?

		Totally Agree	Agree	Not sure	Disagree	Totally Disagree
	I think I am very good at doing experiments or practical works in science lessons.					
	I think I am very good at coming up with questions about science.					
	I think I am a successful science participant.					

	I think I have a good performance in science activities.					

42. Please, think about **science and your religion,** which one is easier to ignore when you make important decision?

( ) For me, it is easier to ignore my religion than science.

( ) For me, it is easier to ignore science than my religion.

( ) For me, both science and religion are difficult to ignore.

( ) I think I could easily ignore both of them.

43. Please, think about **science and your gender**, which one is easier to ignore when you make important decision?

( ) For me, it is easier to ignore my gender than science.

( ) For me, it is easier to ignore science than my gender.

( ) For me, both science and my gender are difficult to ignore.

( ) I think I could easily ignore both of them.

44. Please think about **science and your ethnicity,** which one is easier to ignore when you make important decision?

( ) For me, it is easier to ignore my ethnicity than science.

( ) For me, it is easier to ignore science than my ethnicity.

( ) For me, both science and my ethnicity are difficult to ignore.

( ) I think I could easily ignore both of them.

45. Please think about **your religion and your gender,** which one is easier to ignore when you make important decision?

( ) For me, it is easier to ignore my religion than my gender.

( ) For me, it is easier to ignore my gender than my religion.

( ) For me, both my gender and my religion are difficult to ignore.

( ) I think I could easily ignore both of them.

46. Please think about **your religion and your ethnicity,** which one is easier to ignore when you make important decision?

( ) For me, it is easier to ignore my religion than my ethnicity.

( ) For me, it is easier to ignore my ethnicity than my religion.

( ) For me, both my ethnicity and my religion are difficult to ignore.

( ) I think I could easily ignore both of them.

47. Please think about **your gender and your ethnicity** in terms of the degree to which one of them is more difficult for you to put aside.

( ) For me, it is easier to ignore my gender than my ethnicity.

( ) For me, it is easier to ignore my ethnicity than my gender.

( ) For me, both my gender and my ethnicity are difficult to ignore.

( ) I think I could easily ignore both of them.

48. Could please compare how important your religion, science, ethnicity, and gender are in your live? (the most important should be written on the left, and the least important should be written on the right)

……………..>…………………..>…………………..>………………..

49. What kind of career do you see yourself pursuing in the future?

…………………………………………………..

Thank you for your participation.

8.3 Appendix 3: Students Interview Questions

	1. How do you feel about science lessons at school?			
	2. What do you think about science activities outside the school?			
		Gender	**Religion**	**Ethnicity**
Science Person: Identification/ Recognition	3. Could you share your thoughts on the characteristics of a science person? [Alternative points to ask: how a science person behaves, what a science person does, what qualities define a science person?]	Science Person *if student say yes for being science person (identification/recognition)*:		

	4. Could you share your thoughts on the characteristics of a scientist? [Alternative points to ask: how a scientist behaves, what a scientist does, what qualities define a scientist?]	How may your gender influence your being a science person?	How may your religion impact on your being a science person?	How may your ethnicity impact on your being a science person?
	5. Could you describe a person who works in science-related fields? [Alternative points to ask: what kind of qualities they may have, what they do as a person in science fields?]			

8.4 Appendix 4: Teachers Interview Questions

Name of the teacher:

Date of interview:

1. Could you tell me something about you?

   For example:

   How long have you been teaching science?

   What is your specialist in science subjects to teach? I know science teachers teach triple science, but do you have any personal specialism?

2. How do you think/feel about science?
3. What made you become science teacher?
4. How do you think about teaching science?
5. How do you feel about teaching science to 13-14-year-old students?
6. Have you experienced any rewarding situation because of being science teacher?
7. What do you think about “being science person”?

   When you hear ‘science person’ how that person could be?

8. Do you think you are a science person?

   If yes, what makes you think like in that way?

9. How do you think about being male/female science teacher?

   How do you think about your gender’s impact(s) on being science teacher?

10. If you don’t mind, could you tell me your ethnic background?

    How do you think about your ethnicity’s impact(s) on being science teacher?

11. If you don’t mind, do you have any particular religious or spiritual beliefs?

    If yes, could you tell me some about it

    How do you think about your religious or spiritual beliefs impact(s) on being science teacher?

Following questions based on students….

12. Could you please tell me about backgrounds of students you teach?
13. How do you identify a student as a science kind of person?
14. Could you please tell me how different your students are in terms of being science person?

    For example, some students may show obvious science interest, confidence, have career plan in science field…... Some may not show these…...
15. How do you think about competence of your students in science lessons when you think s/he is a science person?
16. Do you give information about work related to science (field) and/or potential career pathways?
17. Could you please tell me about your students' science interest?

    [Alternative questions, if necessary to open up the previous question:

    - *How students' interest changes over time during the key stage 3 if it changes?*
    - *What make them more interested in science?]*
18. When you think if a student is a science person, does the student identification with science coherent with how you think?

Science person:

19. How do you think about genders of your students and their genders' impact(s) on being science person?
20. How do you think about your students' religions and their religions' impact(s) on being science person?
21. How do you think about your students' ethnicity and their ethnicities' impact(s) on being science person?

Science interest:

22. How do you think about students' science interest regarding being boy and girl?

23. How do you think about students' religion and its influence on their science interest?
24. How do you think about students' ethnicity/race and their impacts on students' science interest?

Competence in science:

25. How do you think about students' competence in science in terms of being boy and girl?
26. How do you think about students' religion and its impacts on their competence in science?
27. How do you think about students' ethnicity/race and its impacts on their competence in science?

Career plan:

28. How do you think about your students' career plan in science when consider their gender?
29. How do you think about your students' career plan in science when consider their religion?
30. How do you think about your students' career plan in science when consider their ethnicity/race?
31. How do you think about girls who have minority background ethnicity/race regarding their standpoint to science? Could you please share your experiences/thoughts about these?
32. How do you think about girls considering believer of different religion regarding their standpoint to science? Could you please share your experiences/thoughts about these?
33. How do you think about girls considering their various ethnicity/race and believer of different religion regarding their standpoint to science? Could you please share your experiences/thoughts about these?
34. How do you think about boys regarding?
    - Their ethnic background?

- Their religious values?
- When considering their ethnic background and religions

8.5 Statistically insignificant chi-square test results

Chi-square test results related to gender

The association of students 'gender and expected to behave in a specific way based on your gender was analysed by conducting a chi-square test.

Gender * Expected Gender Behaviours

		Expected Gender Behaviours		
		Yes	No	Total
Gender	Male	48	16	64
	Female	49	21	70
	Non-binary	3	0	3
	Rather not say	3	2	5
Total		103	39	142

Chi-square value	1.95
Degrees of Freedom	3
p-value	0.583
When checked against the critical value table with the 0.05 level of significance, the results showed no association. As p>.05, there is insufficient evidence to reject the null hypothesis.	

The association of students' gender and parents' discussion about the impact of gender on students' future career plans was analysed by conducting chi-square test.

Gender * Parents' Talk about Gender and Career

		Parents' Talk about Gender and Career		
		Yes	No	Total
Gender	Male	21	42	63
	Female	21	49	70
	Non-binary	1	2	3
	Rather not say	1	4	5
Total		44	97	141

Chi-square value	.479
Degrees of Freedom	3
p-value	0.923
When checked against the critical value table with the 0.05 level of significance, the results showed no association. As p>.05, there is insufficient evidence to reject the null hypothesis.	

The link between students' gender and gender impacts on career choices was analysed by conducting chi-square test.

Gender * Importance of Gender in Career Decision-Making

		Importance of Gender in Career Decision-Making					
		Not sure	No influence at all	Little influence	Some influence	Great deal influence	Total
Gender	Male	11	10	13	18	12	64
	Female	6	16	15	26	5	68
	Non-binary	1	1	0	0	0	2
	Rather not say	1	2	0	0	2	5
Total		19	29	28	44	19	139

Chi-square value	17.526
Degrees of Freedom	12
p-value	0.131
When checked against the critical value table with the 0.05 level of significance, the results showed no association. As p>.05, there is insufficient evidence to reject the null hypothesis.	

The relationship between expected to behave in a specific way based on your gender and parents' discussion about the impact of gender on your future career plans was analysed by conducting chi-square test.

Expected Gender Behaviour * Parents' Talks about Gender and Career

		Parents' Talks about Gender and Career		
		Yes	No	Total
Expected Gender Behaviour	Yes	37	67	104
	No	7	31	38
Total		44	98	142

Chi-square value	3.83
Degrees of Freedom	1
p-value	0.05
In terms of the association between expected gender behaviour and parents talking about gender impacts on careers, the chi-square test result shows that the p-value is close to the conventional significance level of 0.05. So, there may be a possibility of a relationship between these two variables, but it is not highly significant or particularly meaningful. When p =.05, there is insufficient evidence to reject the null hypothesis.	

Chi-square test results related to ethnicity

To explore association between Ethnicity and Importance of ethnicity for students, chi-square analysis was conducted.

Ethnicity * Importance of Ethnicity

		Importance of Ethnicity					Total
		Not important	Not very important	Moderately important	Important	Extremely important	
Ethnicity	White, or	4	4	6	11	12	37
	Mixed/Multiple ethnic groups, or	0	1	2	4	5	12
	Asian/Asian British, or	3	2	9	24	13	51
	Black/African/Caribbean/Black British, or	1	2	1	9	5	18
	Chinese, or	1	0	0	1	1	3
	Arab, or	0	0	0	5	9	14
	Other ethnic group	1	0	0	1	0	2
Total		10	9	18	55	45	137

Chi-square value	26.87
Degrees of Freedom	24

p-value	0.311
When checked against the critical value table with the 0.05 level of significance, these results showed no association between ethnicity and importance of ethnicity. As p>.05, there is insufficient evidence to reject the null hypothesis.	

To explore association of Ethnicity and Parents' talk about ethnicity, chi-square analysis was conducted.

Ethnicity * Parents' Talk about Ethnicity

		Parents' Talk about Ethnicity		
		Yes	No	Total
Ethnicity	White, or	29	8	37
	Mixed/Multiple ethnic groups, or	10	2	12
	Asian/Asian British, or	47	4	51
	Black/African/Caribbean/Black British, or	16	2	18
	Chinese, or	2	1	3
	Arab, or	14	0	14
	Other ethnic group	2	0	2
Total		120	17	137

Chi-square value	7.57
Degrees of Freedom	6
p-value	0.271
When checked against the critical value table with the 0.05 level of significance, the results showed no association between ethnicity and parents' talk about ethnicity. As p>.05, there is insufficient evidence to reject the null hypothesis.	

To explore association of Ethnicity and Parents' talk about ethnicity and career, chi-square analysis was conducted.

Ethnicity * Parents' Talk about Ethnicity and Career

		Parents' Talk about Ethnicity and Career		
		Yes	No	Total
Ethnicity	White, or	8	24	32
	Mixed/Multiple ethnic groups, or	0	10	10
	Asian/Asian British, or	12	38	50
	Black/African/Caribbean/Black British, or	8	9	17
	Chinese, or	1	2	3

	Arab, or	4	10	14
	Other ethnic group	0	2	2
Total		33	95	128

Chi-square value	8.43
Degrees of Freedom	6
p-value	0.208
When checked against the critical value table with the 0.05 level of significance, the results showed no association between ethnicity and parents' talk about ethnicity and career. As p>.05, there is insufficient evidence to reject the null hypothesis.	

To explore association between Ethnicity and The importance of ethnicity in career decision making, chi-square analysis was conducted.

Ethnicity * Importance of Ethnicity in Career Decision-Making

		Importance of Ethnicity in Career Decision-Making					
		Not sure	No influence at all	Little influence	Some influence	Great deal influence	Total
Ethnicity	White, or	3	10	14	8	2	37
	Mixed/ Multiple	2	5	3	1	1	12

	ethnic groups, or						
	Asian/ Asian British, or	6	13	17	10	4	50
	Black/ African/Caribbean /Black British, or	1	4	6	4	2	17
	Chinese, or	1	0	0	2	0	3
	Arab, or	2	2	4	4	2	14
	Other ethnic group	0	1	0	0	1	2
Total		15	35	44	29	12	135

Chi-square value	18.12
Degrees of Freedom	24

p-value	0.797
Related to ethnicity and the importance of ethnicity in career decision making, when checked against the critical value table with the 0.05 level of significance, the results showed no association. As p>.05, there is insufficient evidence to reject the null hypothesis.	

To explore association of Importance of ethnicity for students and Parents' talk about ethnicity and career, chi-square analysis was conducted.

Importance of Ethnicity for Students* Parents' Talk about Ethnicity and Career

		Parents' Talk about Ethnicity and Career		
		Yes	No	Total
Importance of Ethnicity	Not important	1	8	9
	Not very important	1	7	8
	Moderately important	2	12	14
	Important	14	40	54
	Extremely important	17	30	47
Total		35	97	132

Chi-square value	5.23

Degrees of Freedom	4
p-value	0.264
When checked against the critical value table with the 0.05 level of significance, the results showed no association. As p>.05, there is insufficient evidence to reject the null hypothesis.	

To explore association of Importance of ethnicity for students and The importance of ethnicity in career decision making, chi-square analysis was conducted.

Importance of Ethnicity for Students * The Importance of Ethnicity in Career Decision-Making

		The importance of ethnicity in career decision-making					
		Not sure	No influence at all	Little influence	Some influence	Great deal influence	Total
Importance of Ethnicity	Not important	3	4	2	0	2	11
	Not very important	2	3	4	0	0	9
	Moderately important	0	5	7	6	0	18
	Important	7	12	17	15	3	54

	Extremely important	4	12	14	8	7	45
Total		16	36	44	29	12	137

Chi-square value	21.28
Degrees of Freedom	16
p-value	0.168
When checked against the critical value table with the 0.05 level of significance, the results showed no association between the variables of importance of ethnicity for students and ethnicity importance on decision making about career. As p>.05, there is insufficient evidence to reject the null hypothesis.	

To explore association of parents' talk about ethnicity, and Parents' talk about ethnicity and career, chi-square analysis was conducted.

Parents' Talk about Ethnicity * Parents' Talk about Ethnicity and Career

		Parents' Talk about Ethnicity and Career		
		Yes	No	Total
Parents' Talk about Ethnicity	Yes	31	88	119
	No	4	9	13

Total	35	97	132

Chi-square value	0.134
Degrees of Freedom	1
p-value	0.714
When checked against the critical value table with the 0.05 level of significance, the results showed no association. As p>.05, there is insufficient evidence to reject the null hypothesis.	

To explore association of parents' talk about ethnicity and the importance of ethnicity in career decision making, chi-square analysis was conducted.

Parents' Talk about Ethnicity * The Importance of Ethnicity in Career Decision-Making

		The importance of ethnicity in career decision-making					
		Not sure	No influence at all	Little influence	Some influence	Great deal influence	Total
Parents' Talk about Ethnicity	Yes	11	33	38	26	11	119
	No	5	3	6	3	1	18

Total	16	36	44	29	12	137

Chi-square value	5.77
Degrees of Freedom	4
p-value	0.216
When checked against the critical value table with the 0.05 level of significance, the results showed no association between parents' talk about ethnicity and the importance of ethnicity in career decision making. As p>.05, there is insufficient evidence to reject the null hypothesis.	

8.6 Andreea Interview Transcription

R is for researcher, and S is for student.

R: Thank you so much again for being a volunteer for the interview and letting me record our conversation. Today is the 6th of June. If you have any questions, I am happy to answer them now or later. Also, your name will remain anonymous in my research and any reports or publications. Just to confirm, these are recording. Okay, all fine. How do you feel about science lessons at school?

S: They are easy and interesting.

R: Okay.

S: Yeah.

R: Do you attend science activities outside of school?

S: No.

R: There is a term "science person." What do you think defines a science person?

S: Someone who prefers straightforward questions and is good at math, not necessarily someone who likes writing essays in English.

R: Okay. How about a scientist? What do you think about scientists?

S: Someone who is interested in researching new things and contributing to society from a science perspective.

R: While you are distinguishing between a science person and a scientist, what could be the difference?

S: A science person could be someone who likes science and enjoys studying it, but a scientist is someone who has studied it for a long time, focuses on one area of science, and has qualifications.

R: Do you think you are a science person?

S: I prefer science and math as subjects, but I also like English and history. Yes, I think I am a science person.

R: Do you think people around you, like your family, friends, and teachers, think you are a science person?

S: Yes, I think they think so.

R: Your family or friends?

S: I think my family and friends.

R: How about your teachers?

S: Yes, I think they also think I am a science person.

R: How would you rate your interest in science, on a scale from 0 to 10?

S: 7.

R: What makes you think your interest level is around 7?

S: I enjoy it and find it easy. I like doing it at school but wouldn't't necessarily engage in science activities outside of school.

R: Regarding science activities, do you watch any science-related TV shows or videos outside of school?

S: The most science-related thing I watch is crime documentaries.

R: Any books you read related to science?

S: No.

R: Alright, have you experienced any rewarding situations while learning science?

S: Like what?

R: Something that made you proud of yourself or happy.

S: Most of my science lessons at school, I know most of the answers, and I do well on science tests, like in math too.

R: How confident are you in science lessons?

S: Pretty confident.

R: How do you feel when you are busy with an experiment or activity in science lessons?

S: I am really into it and enjoy it. I feel like I am making progress quickly.

R: Do you have any career plans in science?

S: I was thinking about forensic science, the crime-solving side of science.

R: Regarding being a science person, do you think your gender influences your identity as a science person?

S: No.

R: Do you believe in any religion?

S: Yes.

R: Do you think your religion influences your learning or being a science person?

S: No, I don't think my religion impacts how much I believe in science, but science could impact my religion because I believe mostly in facts and science. It kind of contradicts itself a bit.

R: Do you think your ethnicity or your ethnic background influences your being a science person?

S: No.

R: Do you think your gender influences your science interest?

S: No.

R: Any impacts of your religion on your science interest level?

S: Yes, it made me more interested because I want to make a link between the two. I want to believe in both at the same time, and it made me more interested in finding out how I can do that.

R: Which religion do you believe in?

S: I am Christian, Orthodox.

R: While there is a conflict between science and your religion, how do you resolve the problem?

S: I go off to find out and consider what my parents and religious places tell me. I make up my mind about what I think is more reasonable and logical because I am a logical person.

R: Could you give me any example if you experienced anything like this?

S: [Laughs] No.

R: That's fine. Okay, how about the impact of your ethnicity on your science interest?

S: It also made me more interested because it is uncommon in my country to go to university and be in STEM. It's a more corrupt country and people really don't have the money to go, so it made me more interested in reaching higher.

R: Do you mind if I ask your ethnic background?

S: I am Romanian.

R: Is there any influence of your gender on your confidence in science?

S: No.

R: How about your religion? Do you think it has any influence on your confidence in science?

S: No.

R: How about your ethnicity?

S: No.

R: Related to your career plans, do you think your gender has any impacts on planning to be in the science field?

S: No.

R: How about your religion and its impact on your career plan?

S: No.

R: And your ethnicity influence related to your career plan?

S: It makes it a little bit harder because there is still some discrimination, but I don't think it highly influences me.

R: Oh, discrimination because of your ethnic background?

S: Yes.

R: How about the discrimination because of gender? Do you think there will be?

S: Yes, because women in STEM is quite new. It's more recent for there to be more women in STEM.

R: So maybe it is early for you to think about these, but I just wonder what is your plan to deal with discrimination because of your gender, ethnicity, or religion in these fields?

S: I don’t know, I guess just work harder and prove them wrong.

R: Alright.

S: Just like that.

R: Have you experienced anything similar during science lessons?

S: Here, no, because at this school there are so many different backgrounds and religions, so no one really discriminates against each other.

R: How about gender? Any experiences because of being female?

S: No, I don’t think there is anything.

R: Okay, have your parents talked to you about your gender?

S: Sometimes.

R: What do they say related to your gender, such as expected behaviour?

S: They generally said it doesn’t matter. You just have to work hard to get what you want to be. It doesn’t matter what other people say about your gender.

R: I see, that’s nice. It sounds like they are mostly encouraging you and not taking gender-related ideas into account. So, any speech of your parents or talk about your ethnic background with your parents?

S: Not really, we talked about how sometimes there is discrimination because of where we are from and the stereotypes around what we are supposed to do as jobs, but they mainly said again just mind your business and prove them all wrong.

R: So, regarding the cultural values, do your parents share any cultural values to let you know about those things?

S: Yes.

R: Have your parents talked to you about your religion?

S: Yes.

R: What kind of speech is that?

S: My parents never really force religion on me. They said you are going to decide what you want to believe. We are going to tell you if you ask, but unless we are not going to force religion on you.

R: Alright. Have your parents talked to you about you being good at science?

S: Yes, they know I am more interested in science and they know I am better at it than other things.

R: How about science interest, do they talk to you about your science interest or to motivate you in the science field?

S: They ask me if I need help and they try to get me help since they are not too knowledgeable in science. That's not their careers, so they just try to help me where they can and then ask for external help where they can.

R: Okay, have your parents talked to you about your career plan?

S: Yes. They have talked about trying to do something that you like and you can enjoy what you are going to do, not just something other people tell you to do.

R: Did you tell your parent about your career plan in the future, if yes what do they think about that?

S: They think it is good and they just think it is going to be really hard but as long as I work hard and do what I am supposed to do then I should be fine.

R: Okay, so do they want you to study related to science?

S: Yes, my parents would like me to study something in science, math, or something in these fields.

R: Is that important to you, for you to satisfy your parents by taking their advice into account?

S: Yes.

R: While talking about these things with your parents, how do you feel?

S: Mainly, they mostly agree with me. They just tell me what you want to do.

R: Could you think altogether of being a girl, having religious beliefs, and having your background, all together while you are interpreting your being a science person?

S: No, I can't really say I have experienced anything just because of being Christian or a girl.

R: How about during the lessons? Having all these combinations of values influence your science learning?

S: No.

R: What do you think a science person does as a job?

S: Medicine, like someone working in a lab studying biology, chemistry, or as a pharmacist.

R: How about the scientist? What does a scientist do as a job?

S: Scientists help people from other fields. They do lab work, they conduct investigations and experiments, not just for their own field.

R: Is there anything you would like to change to make science lessons better?

S: Science lessons are a lot of theory. You see and write and memorize it. It could be more interactive, more activity, actually having something in front of you to see it, not just a picture on the board or words on the board.

R: Did you see any friend who is a girl but not feeling as confident as you are in science lessons?

S: I do have a friend who is a girl and not as confident and not as interested in science, but I don't think it has anything to do with gender, religion, or ethnicity, but rather personal interest.

R: Did you hear anything maybe complaining such as 'oh, boys are targeting us because of our gender' or something like that from your classmates?

S: I have heard stupid comments like 'go back to the kitchen,' but I just try to ignore them. Boys sometimes get out of hand, and I am like 'look, stop, it is not, you are saying something dumb.'

R: Any more experiences of this kind of misbehaviour from boys in science lessons?

S: Not really, I could only say it is just teenage stuff, and they all will realize one day it was stupid and they probably made a mistake, but I don't take it too personally.

R: If there is any specific religion or ethnic background of those boys who were saying these things?

S: I don't think it is one specific ethnicity, background, or religion.

R: How does your teacher react to these situations?

S: If you tell them, they definitely react and say, ‘oh no, that’s not okay,’ and punish them accordingly, but most of the time teachers are not involved, and I can just ignore them and tell them ‘boys, this is stupid, just stop.’

R: I don’t have any more questions. Thank you so much for participating. If you have anything to tell or ask, please let me know.

S: Have a good day.

R: You too.

8.7 Lucia Interview Transcription

R is for researcher, and T is for teacher.

R: The first set of questions will be based on your experiences and education received. How long have you been teaching science?

T: This is the third year.

R: What is your specialization in science?

T: In here it is chemistry.

R: What did you study in your undergrad degree?

T: Science and technology applied to cultural heritage. It’s not one science; it’s a variety of sciences applied to the study of ancient artifacts and similar things.

R: How do you feel about science?

T: Oh, I love it. [laugh]

R: Anything you would like to add?

T: I like to do something that is not just for scientists. It is something that I think anyone of us can do. It’s an interesting perspective that can trigger curiosity, that can answer questions but also push you towards new questions, and go in-depth into what you’re interested in. It gives you a method of finding your answers. So yes, I like the part of science that is not just about giving answers but that makes you question what is around you and provides you with a method to try to understand it.

R: What made you become a science teacher?

T: I always wanted to be a scientist. I was working in academia, have a PhD, and during the PhD, I began working with students in the outreach programmes, which I really liked. It was very satisfying. Academia was a bit stressful, but every time I dealt with students, it was surprisingly satisfying even if it was manic. For a variety of reasons, I decided to become a science teacher in Italy, but for personal reasons, I ended up in England and began teaching science here.

R: How do you feel about being a science teacher?

T: I really like it, and I think I like it here even more than what I did in Italy because the school might have more or less practical work. Here it gave me and the students the possibility to practice. Science is not just about possibilities or hypotheses; it's hard work in front of you, evidence you need to observe, and you need to be curious. I like the fact that it involves your brain but also your hands, and the communication between people. I always tell them it's just science, it is work done by many, so everyone needs to pitch in.

R: How do you feel about teaching science to the Year 10 students?

T: I actually like the younger group for different reasons. They tend to have a spark in respect to science and experiments, which is probably said by everyone. Year 7 arrives and anything you do, they are like "wow", this is kind of satisfaction. On the other side, as you might have more challenging conversations with older students, they are becoming more mature but it depends on the kids. I did teach Key Stage 3 and 4, each age group has its excitement and curiosity, like the progressive maturity with the older groups.

R: Have you experienced any rewarding situations because of being a science teacher?

T: I think every time kids ask questions starting from what we're doing in class and applying it to what is around them or what is causing it, and feel that they can ask that question, all what we're doing triggers that question and we can discuss it. It is extremely rewarding because, at the end of the day, yes, we are delivering our curriculum but the idea is that they are able to connect it to the real world, and what they love and sparked their interest. When they make good questions which are not just curriculum, about something else connected, that link, that is really satisfying.

R: What do you think about being a science person?

T: Having been working in academia as a scientist, I love science and reading about science. I think that science permeates everything we do; it's just about having sometimes "science glasses" that kids put on, like we're putting our physics or biology glasses on. I think I'm quite sciency, but at the same time, it's just because currently, I feel like my science teaching is taking up a bit too much of my other parts. I feel like I am a scientist but I also have other parts. My qualification when I was in the PhD was working in cultural heritage, and sometimes I miss that. So sometimes I get very focused on my science bit, and I'm like, "Yes I love my science part," but remember that there is identity, so in these specific moments, I am a bit without a personal fight with myself. Yes, you are a science person but there's also something else, but this is, I think it is also a tiny bit normal that we go through identity crises, just because I chose a path which was combining two things I loved: art and science, and now I'm doing one and I'm not having much time for the other one, but this is about work-life balance and I think about being a teacher in person. [laugh]

R: [laugh] I see, when you hear the term science person, or when you need to describe a science person, how would that person be?

T: I think it is about, like everything about being a science person I have found it a bit, I am not sure about how I feel about the word science person, because one thing is a scientist, and like a science person what does it actually mean? It is a person who likes science, it is a person that applies science, it is a person who is interested in science. So if we have to identify as a general term, I could say that it is any type of person that does have any interest in science for whatever reason, in my view, either apply it or where it is using a specific method, but I wouldn't want to exclude also people that are not applying it, but I assume they are interested in it. So, people that do have science as a passion, so you have a completely different job as our kids might have but they love going to the Science Museum, they might love to do astronomy and they may have a telescope at home. So, I think that science person can be a very broad term we can apply, and I think in a very useful way to make sure that everyone can feel like they can be a science person like science is with us like we use our language.

R: Okay, thank you. Do you think you are a science person?

T: My parts say definitely yes.

R: What makes you think that way?

T: I think as we were saying, all the specific interests in topics or ways that you are approaching life, so how is it that you are approaching life around you, like in, I don't know, if a person is systematic, is looking for evidence, you know, like this and systematic method applied around you and at the same time, I would say that we need to put together the fact that it might just be because you love science, because yes sometimes I have a very scientific method in approaching certain things, about sometimes in life absolutely not, it is the complete opposite, so it's about specific shades that commentate what is science and not necessarily being a scientist, so one thing is a scientist, another thing is a science person, those are different.

R: How do you feel about being a female science teacher?

T: Well I think it is quite empowering for our students to have role models, especially when I tell them that I have got a PhD, so I also think that is a learning moment for them about what does it mean to have a PhD, why there is, I've never used doctor in front of my name ever in my life until when I started teaching, that is the first time I put doctor in front of it, and this was because another teacher told me that no you have to put it, because you have and you are female, you have to show that females get used it, but also because you have worked hard for it, and you can use that as a point to show them, and also wider knowledge about what does it mean to research, what is after school, so what we're studying how it is actually, you know, developed, and suffering, so they are like why is there a doctor in front of it, are you going to come to me if you've got a cold, you know and there is a full, it depends again on the kids you've got in front of you, but for our kids that have very limited science capital, and in general a very limited cultural capital, knowing the difference between the doctor that you go to the GP, and the fact that there are people that are selling things at university and then you get that, it is opening again, the pathways, so is something there is also this route, yeah, and, and yes and there is the usual context about having a science degree as a female, you know, the numbers are a bit lower, it is disappointing, but of course you can do it.

R: How do you think about gender impacts on being a science teacher?

T: Well, I, I find it difficult not to make the comparison with what I had before, because coming from academia and seeing how it is in teaching, also coming from another country, so for me there are a lot of things put together, and, one of the things that, besides the limitations one of the things that I think is quite good, I am teaching reproduction currently, and I do think that, for example, being a female, yes, maybe I, I can't connect with some specific things that the boys are feeling, but it's I think reduces in certain cases the stress on the girls, so everyone is feeling a tiny bit more comfortable about talking, I don't know, about menstruation etc, yeah they all find it extremely awkward, but I have been told sometimes, but my male science teachers that because there is all the cultural especially like in the school but when you have kids do come from backgrounds where there is a very strict separation, that they do not talk about the subjects of course up and so I do feel that being a female I can, I can, I don't know, or find it like less challenging way sometimes, and I think that is quite, quite powerful, and for especially for specific topics, and in other situations instead is not about the fact that I'm a science teacher is because I'm a female teacher, so that there are instead issues related to the fact that there is a lower respective authority, because I am a female, that is not, that's not because I'm a science teacher, this because I'm a female, so whereas instead of being a female science teacher, I think it's actually very powerful.

R: If you don't mind, could you tell me your ethnic background?

T: I am Italian.

R: How do you think about your ethnicity impacts on being a science teacher?

T: Well, I've got a lot of references to talk like, I can talk like a year, you know all these, Da Vinci, Galileo, whatever and I do also know, where we were all told like in Italy we have such a strong scientific background, like historically and in terms also of the education, and then we all fly away, but yes, I, I think that it makes it very interesting for a doctoral references, which are very, very useful in the class and make it a bit more real to sometimes lower bit the tension, and get out just a concept like gravity, you know how the people that were just dropping it from the tower of Pisa, have you seen the monkeys very famous, have you seen the pictures, only people holding with the finger, you know these are just like tiny little things, and the thing there are so many so many, so it's quite nice.

R: If you don't mind, do you believe in any particular religious or spiritual beliefs?

T: So, I am agnostic, so and as a scientist as evidence, or maybe not, but, I'm, Italy is a Catholic country, and that is what I learnt from that as because my mother is, she did not baptize me and she was like it's going to be your choice, I anyway come from a family that was like I'm not gonna put this decision in, you will choose it, so she offered me to variety we had to book the religious and everything, at certain point I did want to get baptized and then I didn't really like the environment, so I made my own choices, and was also interesting to talk with other like colleagues in Italy, they were religious, we have all Catholic but at the same time they are secular, I was saying, and so whereas in here, sometimes I do challenge the fact that, I mean, I don't know, but they don't know that I don't know, and we are all with different religions in the class and I make very much the point of respecting each other, the reasons coming especially from what I can do, where there isn't one main religion which I do have found all the powering sometimes like that is not their business, that is my life, I am very keen on even in my class, that is a personal thing, we respect because it's your personal belief, but it doesn't have to go on the others, how many 10 15 different ethnicity in the class everyone is going to have a different religion, are they wrong or right, nothing it is personal, we respect it so the anything, that does come from my Italian background that yeah man this is like that's all fine.

R: How do you think about your agnostic beliefs impacts on being a science teacher?

T: Oh I think that because, I mean, one of the thing is like I'm not sure, so like in science you do have to be open to any evidence, and I really like that because when I tell them remember that when we teaching theory, that is not that scientists are lying to you, you know, is the fact that we begin having better tools we begin having better knowledge so in science, we really need to be open to make the leap, because you need to be an open person, that you need to follow the data, you not believing in science, you don't believe in science, you look at the data and you follow the data and you always remember that science is an interpretation, science is a way of explaining and, and finding a meaning that it needs to be based on evidence, it is not something you can't say like I believe in science, yes one way, of course, you can say it but you don't believe in the experiment, you look at the data and maybe the experience gone wrong, and you do it again, and you do it again, so these, sometimes that is like trust in the method, like believing in the scientific method rather than in science itself, I think it is in a good direction to respect, to respecting also the others, I don't know.

R: Could you please tell me about the background of your students?

T: As I said there are like variety, I've got, I've got the kids from Romania, we got some Ukrainian kids, we've got kids from Italy, Afghanistan, Middle East, we have really diverse background, which makes it really beautiful, I think it is a bit London thing, but I think in this specific school we do really have varied population, I think this is a beautiful part, it could be very strong part of the community, I do think sometimes if it is brought together it is better.

R: How do you identify a student as a science kind of person?

T: Ah, for me, sometimes they tell me like ‘I am not good at science’ and I am like ‘why is that, that’s rubbish, that’s rubbish, because you are just not confident with that topic’, so I really push on the you can be, at first I don’t say you are, I don’t say to them because if I say you are they might not be, I really try to avoid it, I may say you like science, it is very clear when you like science, it is because I do have kids they come up because they are extremely interested in other topics and they come up with different questions, and asking questions, they just, they just love it, and not necessarily high grades, which means that if you are a science person you might be just an excellent student is achieving every single subject, and you might even dislike science, we just have to do it, so it’s not about grades, it’s not about the result, for me and I don’t tell them, but it’s about how much you’re enjoying the subject, they might have a scientific mindset so that they aren’t very methodical, but again you can have a scientific mindset or also if you are a tiny bit more mathematical or I don’t know scientific, type of scientific methods also could be applied to social sciences etc, is that type of mindset, not necessarily science in the sense that we need in respect to physical sciences, so, so for me when I look at the kids, ‘he likes it so much, he’s enjoying it so much, he has got such a scientific mindset, oh my gosh he is so methodical’, but I don’t tell them you’re a science person unless it isn’t a private conversation because I don’t want to put down the others, so I want to be as inclusive as possible, and yeah.

R: So, in terms of being a science person how do you think about ethnicity impacts on being a science person?

T: I don’t know, to be fair, because it is so various, any changes across the class and I haven’t tracked it, I can’t really say all this specific background is making the kids, the thing is that we do, I do, what I noticed I do have quite a few kids like they are oh I wanna be doctor, but I think that is kind of another situation, so, so for the moment I have, I have not observed specific background that they want to be scientists, doctor yes, the scientists are not exactly, it’s very varied.

R: It is, depends on the kids, so I haven't, I haven't notice all, like all my kids are coming from, I don't know, east Europe want to be scientist, all my kids are coming from that, it is completely depending on the kids, so if I had kids which were very science interested, in the case of my classes specifically and I get, I have not tracked it, so maybe he doing how do you feel about science in a more structured way, because maybe we have done it in class and I don't remember it absolutely, because he would have been, in normally you would have Year 7s or 8s when you meet them, and I've got three year 7 classes and my classes are old ones, older ones, but then I normally use it for, 'oh they are gonna use that and I can use that to show you how science is everywhere' etc, and how you know to open their minds, so as a scientist I don't have the information exactly to tell you whatever the reason not I haven't notice anything apart from the doctors.

R: How about the doctor ones?

T: I think, the doctor ones are generally from Indians and Bangladeshi kids.

R: What do you think about this, I mean, how they get this like interests?

T: I think it's a bit of in achievement for the family to which type of qualification, what is associated to being a doctor in respect to the professional where they're coming from, the job that I think has more to do with the what is a doctor in their society, so and sometimes I also do think that I don't say it, but it is a bit of, you know, working hard enough at all for becoming a doctor, your, to become a doctor you need to have a professional ethic, and work ethic which is above at the top, and the little one, and I am very sorry, currently you will change, but to become a doctor you need to have extremely high grades, you need to have that very high fly path, and some of them do, some of them do show these, so sometimes I think is a bit also of a bit of a push from parents, and a bit of or want to become that not maybe because I really like it, just because that is, but didn't understanding what does it means to them, but I don't say it because you never know for example I don't want to be the teacher, but all you will never become a doctor, and also there are kids they might snap into it the year after I've got them in your, in Year 10 and in the Year 11, and then they suddenly change, and we have seen this I mean I've seen some of my Year 10s and in Year 11s, oh gosh there is the switch that they suddenly understand that they're going to do GCSEs, and they do need to have those high grades to get into a good 6th forms and to access the specific subjects, and so at the same time, you know.

R: In terms of being a science person, but also in terms of having a science identity, I need to give a short information about how I conceptualized science identity, so science identity based on identification as a science person, or recognition as a science person, and also based on the students' interests, and the confidence in science and having a career plan in science field, so in that case while you like teaching science to the students and when you think one is a science person, how do you distinguish these things?

T: Well because of their background, we do have I actually tried to push the fact that science is for everyone, even if they are not going to pursue a career in science, I make continuous that references to jobs which are not considered scientists, like I don't know hairdressers, or like workers in constructions, so well what do you think it is happening whether it makes help for making the matters, that's gonna hold up the bricks, when they're choosing the type of materials because it has a specific texturally as specific, I don't know, stress, stress resistance whether it is, that is science, so, so I on purpose try to push them on the fact that it could become scientists, but also to make the point that even if they are not, still science is important for them and can help them in everyday life and make a connections, so, yeah, I, I tried compose those.

R: That's good, how do you think about the confidence of the students in science lessons?

T: Well, that is another thing about developing it, when they say I am not good at science, I am like no that's rubbish it is just a though topic what there it is, maybe that is, that is like maybe they are not good at specific approach that we use in science, like for the math start, they do come up with I am not good at science, I am not good at science, but in general when you have sometimes kids which are low ability, but again low ability what low ability he actually meant, maybe they are finding the topic difficult, maybe you need to scaffold it more so separating the task from what they are good at science or not, and also separating the fact like, in science we have mix ability which at the moment is a bit challenging, because their ability is so stretched up, planning for them is very difficult but making the point that you can like science, even if at the beginning or not that confident and we will probably begin like in science more if your ability increases, you feel more confident, you're more pleased with yourself and it is a cycle, so trying to tell them that that's how it works, sometimes you do like things because you're good at them, and not necessarily if you are good at them you actually like them, so showing them that, that can be switched, and also saying it is fine you know some people are very good at it, and some people need to work hard, and I keep telling them that one, I wasn't that smart but I got my PhD, and to make the point where people much smarter than me and if you decided to do something else so is about also the F {something I couldn't understand}, you need to be resilient so I do use normally those situations, to put my point, it is not about I'm good from the start, it is about to put in the effort and looking at what you want, if you start from here and you get that, and also how much you're working with, are you really trying your best, then it is fantastic, well maybe there is another year that coming to you and, and, you know, but you may be suddenly switches so just give it the most the comfort of, yes, sometimes you won't get the results straight away but as long as you work hard, that's what I'm looking that I will never give a concern for not getting it right, but if you're not trying hard that is a problem, that is the problem, not getting the right, especially, with the especially the kids with the dream, doesn't matter what is your grade, the important thing is that you need build your resilience you need to build your methos, and then.

R: Do you give any information about works which are related science field?

T: Yeah, no, definitely, yeah like actually quite frequently, so now, I think I'm not even doing it enough, because, I don't know, I think that when you have to do science capital and you have to look about it, you need to be really thinking about all the situations, and there is so much overload of information, we're teaching this subject you need to check that properly that you're teaching it properly, or where I'm going to put a bit of science capital on here, so I think that also comes with the experience, doing it on purpose, doing it with some research properly, it is not all automatic, but I tried to do it a lot, also, when I was saying before like besides hairdresser example that it was about how do you use science, but I don't know when we're talking about vaccinations and okay whose parents that is a working in a pharmacy, biologists, not necessarily biologists people that work in data analysis which are related to science, or every time it comes up to my mind I do know that I feel like I should, and that's why I was saying there was looking to science capital, it takes a while to try to think really add tags in the topics, and having on purpose in it, because it might pass out from your mind, right, you might or might not think if I said is that, it's like no I need to because every, if it's consistent, you're consistently offering them all these opportunities in the back of their mind, so, yeah, I think it's very much about the consistency on what you're doing, the consistency in pumping him up, yes you can do, it's about the effort, oh there is all these things that you can do', and at the same time comforting them on, because I, I do have a science background, and I do know there are people that do not have a scientific background and perfectly happy with it, and I don't want it to become, 'oh you have to become a scientist' and if you don't want that it's going to push the other ones I say I want to keep the balance of offering, but offering perspective, because working in science I love it, I love this topic, I mean even if I don't still I absolutely love this one, it's amazing, how is it making a bit, a bit of the scene, but trying really keep the balance, because also need to knowledge what are the current interests of my kids.

R: So, in terms of career information like you are giving during the lessons what kind of things are students interested in?

T: I, I need to do a bit of, I did have some people telling me, but, so I, I keep having this thing of the doctors, I did have actually, recently quite a few girls telling me that they want to work in engineering, and I was like 'ohh that is actually good', they are in my science stem club, it did also make sense, but it was engineering, not chemistry or physics, it was engineering which is also very interesting.

R: Is it a rare thing that girl students want to study engineering?

T: Again as a scientist, the fact that that is me telling them, and I haven't asked them consistently is the random information that have come up to me, so normally I won't normally ask them, or what is it that you want to do, I mean, I do actually, but they won't all answer, let's say I might have very sporadic number of people having given me these actual answers, so the one that come to my mind currently, and that I can remember, there are doctors and engineering goals, and I've got a lot of actually psychologists, I think they came up with, but these are normally coming from Year 11s and Year 12s that were talking with me, so from the lower ones, it is, I have to admit I haven't got this moment collection of science-related, maybe some pharmacist, the ones who think about, because they come, because they come to you and you faces when you give them options, like yeah.

R: Could you please tell me about your students' science interest?

T: I would say that normally one of which is kind of expected, when we are doing space, but again, it changes a lot when you've got Key Stage 3 and when you have got Key Stage 4, with Key Stage 3, they are a bit more open about what you do like, especially when you're doing reproduction you're asking, you would, I give them tiny papers, piece of papers that they can write a question anonymously, so any came up a couple of while we learning about it, I still have this can we learn about space or something, yeah I had that can we learn about space and fact, this guy, it was that during reproduction lessons, it was desperate, but when we were doing the topics, for example, for example actually the part of reproduction extremely interested in the foetus development, because it's something that they can see, they ask very interesting questions, some of them are very good questions and some of them misconceptions, like how does the baby eat, and how does the baby poop which for the context I am like this is the perfect question, let's learn that straight away and you're very interested, and also they have seen their mums, so there's something that they can be related to, for other topics that I'm thinking about, I think the other one said the one older when we were doing, for example disease with Year 10s, all the part about vaccination, in fact because of COVID, but I think also in fact because you were talking about sexually transmitted diseases so they were a bit curious, a bit of the topic also, and, yes I'm sure they are actually there are definitely others knowing, the main topics that I saw them really getting a bit curious about, it was when we were doing infectious disease with the triple class and when we were doing the pregnancy with the Year 7, they are generally excited and the time we were doing experiment, they always get over the top, and yes in a way that I do sometimes thing is also depending on the type of population, and you do have that you have more open way of showing the interest, so like they are absolutely fine with I am very interested in it, whereas in some cases they can't show it to you openly, so it might be like asking the question at the end of the lessons, I think that is a kind of a bit of limitation of the context of the classes, and I have done, I have done it with a little bit more efforts, and I think it is also because of incidental limitation, I think which I have, which I have not said the triple classes for generally more participation and showing the interest in that much higher, because I know they all love science because they have chosen triple.

R: How do students' interest change over the time if it does?

T: I do think that in Key Stage 3, they are overall the overall like the idea of science, because it's connected to experiment and because we do experiments in science, really having fun which is hands on, and this is a tiny bit spoiled when we moved to Key Stage 4, because it is so packed with content, it is, it is not about just, or they're going to be in the exams, it is really sometimes, I think, a bit the pace, and also the fact that you really began to see these extreme differences in the, in the effort and in the ability, and, in a mixed ability class which you have kids which are flying really flying to say here's your extensions ideas and others are really struggling with very basic concepts so following that pace is far more difficult, and the fact there is a lot of content, is again, for, it begins being a bit of, I think, not a problem, but of course you know the focus more sometimes on we have to do this and that and we need to carry on with Key Stage 3, there you can manage to protect that, that tiny bit more openly, but Key Stage 4 is, because you need to make sure that effort is up you have to remind them, right, and, there is anyway the fact that the GCSE at their age, we are in a moment in the life where I, I giggle about it, but it is, it is quite true unless you're very interested and you're very keen and they're excellent students like showing effort not showing, showing interest, like I did have personal conversation with students saying if you do the right thing from the start I will not have to remind it to you, you will not be seen that you're complying doing well, I promise I will not praising from the others but do it, right, yeah, because I've seen really people switching their behaviour, so it is clearly this peer pressure about I need to be cool, and he's not I need to be cool in a way that I'm a confident person so I can achieve and I'm interested, so keep telling them you can be cool to your mates but you can also be cool to your teachers, you just need to be smart about it, yeah so don't show that you're complying, just do it, you should have to say nothing, you're getting your results you're working well, you're praised by me, that is the case that is making you switch, and whereas others instead the public praise is important, it is sometimes a bit challenging to, you know, balance this, because it's not depending on just on the classroom on the kid, it depends on the class on some classes and the public praise is absolutely important with other classes in public praise is going to have an adverse reaction, with Key Stage 3 there is no problem, you praising they are absolutely happy, yeah.

R: So having a science identity is related to being recognised as a science person, maybe they just wanted to be known.

T: I don’t think it’s just like the science person, it is also about, you wanna work hard or not, you’re complete working with the teachers or not, like as if following the rules was making you less cool.

R: Okay.

T: So I don’t think it’s just about science, for these students, couple of them I was talking about, it was about peer pressure form from other students which don’t have a good behaviour, and, and in that context because it’s quite challenging if they showed that they are complying with me, then they will be maybe targeted, so it is, you know, so it’s the balance in helping the child to achieve that, and, and finding the confidence, and the moment that you find the confidence you want to praise them, and then you see that they track back, and you are like ‘oh no’, this is what I observed exactly so recently, that a private conversation with the student and phoned home, to make a private praise, there is also privately.

R: How have they reacted that?

T: Privately, like yeah absolutely important very pleased with that, he was like his next to me and everything, but I made, I made really a point in understanding what was the social context in that situation, and also because I, you have friends, they are friends sometimes their friends are not exactly good friends academically, they might sometimes be good friends for other issues but they are kids, they don’t always make good choices, so sometimes also keep them on the science, look he’s your friend, right, how is it doing in this subject, how much he knows, then how much is missing out, right be a good mate, yeah, help him, right, give him a good word, right, so trying but that I don’t think is our science thing, so.

R: But it affects.

T: It definitely does, it does affect but it’s more like general peer pressure in, in teenagers that is far more relevant to the lessons rather than.

R: How do you think about gender of your students and their genders impacts on being a science person?

T: Well, if I look at, at the numbers of the students, I do have quite a few girls which are very interested in science, but I could relate to the fact that despite the type of background they have a family that is really with them, in terms of giving them confidence, in making their choices, and, yeah, because, because of the type of, again I don't want to give information which isn't correct, because it is more a bit of a feeling, so, so I mean within the class, I do have seen that both girls and boys which are interesting science, not necessarily related to gender, it might be more sometimes related to the type of background, but again because we had such a varied background, I can't, I can't make a pattern, you know, because I've got two kids in one ethnicity, and then why does, that is not pattern, yeah, I can't do that that should be like school thing, we have numbers, but I do think that, I do have actually a lot, a lot of girls which are very interested, and I don't know whether it is because they are just interested, or because also in the context they have to be strong, and it would be coming from their being confident and so this showing their interest. I'm pleased to see many strong minded girls, because what they do around them is not as easy, so they need to be strong minded and assertive, and I always try to praise that type of approach, especially on the side of being assertive about what you do, like without pushing the others but being confident is such quite important, for both of course, considering other conditions especially, especially for the girls in that you're able to fight what you want to do like, and want to choose freely.

R: How about, what do you think about your students; religions and their religion's impacts on being a science person?

T: So, so within the classroom, so the impact of the, the direct impact of religion, I ever seen it limited times, I have seen cultural effects which are linked to it, but coming from a religious country I separate it very clearly what is the religion itself and what is the culture that is in your country, so they are not the same thing, and normally I think that within the context of the science classroom, where I'm very clear about the fact that we're talking about evidence, it frames the conversation in a specific way, we might, we might observe an impact but it's not a negative or positive impact, it is more about them showing what they believe when we do approach controversial issues, I don't know, for example it comes up when we were talking about in cloning and, and similar, so but it comes in specific context and, and normally framing the conversation in a way that we must respect the others, and that we also will come in the fact that other people are thinking in a different ways, however it is limited, you know, we don't have that many topics and because we're teaching a variety, it comes up when you're doing those topics, and the only other thing with a kid because of his religion, he can't detach type of animal and he is vegetarian, in any type of vegetarian it wasn't about his religion any type of vegan or vegetarian kid would not want to play with the, with the chicken wings he was actually interested, he didn't touch it, he was extremely interested and asking the other one can you move it, so in that case I didn't really see a negative effect he didn't really lose out because he was actively participating anyway so it's more about the culture related to the religion itself.

R: Okay, so the next question was gonna be the ethnicity, but you mentioned about the cultural impact so I got it, and thank you, so how about the confident, being confident in science classroom, especially impacts of gender on being confident?

T: In that context what I've seen so I do have some girls which are very assertive, and normally if I do have some bold boys which might be stronger academically but extremely confident for completely unrelated reason, I sometimes make quite a point in creating a situation where the, that because I try not to put the boys in all groups, I try to make and mix them up a tiny bit, and, and also in the ability, but I tried to make sure that I don't put up confident and rather arrogant boy next to a weak and unconfident girl, he's gonna go with a very strong and confident girl that will be able to reply back and because anyway during the lesson we have continuous conversations or talk about these talk about that, so to making sure that the person is not, let's, push down by something, the understanding about I think I know more than you, and, the thing I know better than you, and I do think that with our kids there is a bit of a problem with being a bit misogynist, not just so with the with the girls, it's also with the member of staff, so it is ongoing, is ongoing issue, so in that context I make very much about it, we're protecting that the girls which are not quite there yet, or that do not have the family context that is teaching them, yes, you, you know you don't always have to comply with whatever the other are saying even if he's your brother, you're not his secretary, yeah, so but again that is very difficult sometimes, because you know you're in the context of the class, and you can't make the rules but they are bringing that personal habits, and you will try to moderate that, but sometimes it is a bit difficult.

R: Okay, and how do you think about students' religions' impact on students' confidence in science lessons?

T: I, I don't think that there is a direct relationship, so from, from what I've, from what I've seen, it isn't that I've noted that people coming from a specific religion are more or less confident, that is, I think, more family, culture related , there is more family and specific, specific child, so I, I personally have not noticed all kids coming from this background with this specific religion are more or less.

R: So, in terms of ethnicity or the culture, how do you think about the students' ethnicity and its impacts on students' confidence in science then?

T: I think it relates to signing back to what I was discussing before about whether they want to be scientists or not, I haven't really seen a direct, a direct relationship, but because we have so many that I can't really associate one because they are I've got kids which are from different ethnicities, and on the top of my mind I don't, I don't have a bar chart, so I've never done it, because they come from my, my powerful ones who like science do come from different backgrounds, so now that I think about my Year 7s, I do have them from different backgrounds my Year 8s, they come from different backgrounds, so the reasons are, I should use numbers and evidence.

R: Okay, I am not gonna stress you about that but I got what you mean, how do you think about, okay, so the most important part of my research is looking for the intersection of these elements of my research gender, religion and ethnicity, and science, and how do you think when you think all these together and how these influence students' science identity?

T: I think the begin again there is nothing really about the religion, but about the culture so if we put them all together, and I, I exclude a tiny bit my strong ones, my top achievers etc, overall but I have noticed for the others, I do think, that, I do think probably there is a, again, I am not really sure, because, I don't know, because I know there is a differentiation between the kids are pretty able, but also they able to show there is an interest, and they are also sometimes more assertive, because they are getting their ability from their confidence to show it, and also they having the peer pressure in terms of teenager but also the peer pressure from the culture, whereas, others not, I am thinking the especially, girls may not be able to respond to it, so, again, I am not completely sure, it is just the science-related, because it is something that I think that cultural related in respect to the relationship between boys and girls, and boys dictating the girls what is it, or that they have to do, but I try within my classrooms to make that not happen, so there is a moderation about when I was saying before, I try always to put the unconfident girls that you know because you're a bit shy and everything which boys which are respectful which are nice, so that I put them in a situation where they will not have to face that challenge, because I think it's extremely unfair, and I don't want it to happen in a subject which is already very male rendered, so what I'm actually seeing in, in my specific classes is that a lot of the girls are interested in science, so I do not know if it is because our girls are in a context where they have to be strong, they have to show their strong hence in becoming strong, sometimes there is the fact that they are able to choose what they like, but there is also that part of the I'm going to choose what is considered, a male subject, like because I'm strong enough to try to tackle it, right so I don't say it in class, I don't say science is for boys, so it that can happen for me, but that can be something which is in the culture, and I don't know if that is the case, when I think about my strong students whether it is because I'm a female, hence I have more response from girls which again it's introducing, is introducing her wise, introducing her vision in the result, I do have many girls in my mind, but again, I'm a female teacher, and I do have these approach, and I do have a lot of problems with very arrogant boys, because I challenge them a lot, and so there is you know in my answer, I have seen these, but I do think that some of, some of it a good part of it, it is very much related to the fact that I am a female Italian science teacher in a school that has a very high amount of boys that are coming from cultures which is not, for example, Middle East, it is even like Romanian culture, as there is the Italian ones is very masculinist, so I do already come from a culture which is a bit like that, so I recognise this, and is it about science, I'm not completed, I don't think it's about science it is an intersection, so it's very difficult to, to separate it and again when you were saying about the gender and the culture you know because.

R: And the religion.

T: And the religion, so no, you know what I was saying, you know the religion, I don't think it is the religion, it is very much the culture, and also the context of the family, right, because we do have kids they are coming from a specific culture but the child is extremely arrogant, and there are other kids coming from the same religion, same country, of course, the condition of the family is different and the response over the child the one is arrogant towards you but others are very respectful, and again, I can understand you need to this with very big number, myself, because when I look at my classes the variation is so high, if I have 70% of Bangladeshi or Romanian students I can easily make this comparison, if you ask how many languages spoken in this school, it is a little bit crazy, and I have found it absolutely beautiful.

R: Is there a harmony in the classrooms?

T: In the science classroom, I haven't hear, I, I had one incident in the classroom in the past, one called the other one the bloody Afghan, they were friends, they think it is a fun but, in school we try to healthy relationship, friendship like shaking the physical part, but yes, which more present among boys but can't related to specific type of relationships, so, I can't put my finger on exactly a group of ethnicities because I'm seeing it across, but, because the, the ones that we do have, do you specific issues in commons, and I see very much the impact of the family, so it is one I see is very much how much the family can make a difference in what can be an over arcing general issue in the culture, in respectful for example misogyny, and access hands to or what you're going you can't do that, which is a consequence bit, and, and maybe because I'm a female science teacher, the response that do you have more, is from, from girls, so the girls thought you're confident, because I am a science teacher with a PhD, so they feel empowered also in, in coming in, I don't know, this is again hypothesis.

R: I am just curious about when you say your response from the girls, what kind of questions, or advice the girls seeking?

T: I think it's more about the fact that they do ask questions that you are not scared of, you know, the result of telling the kids ask more questions, and Year 7s are normally do have many, there are some topics that they do have questions.

R: Are they asking questions or are they response?

T: And again these are two different things, because one is the, one is about answering the question that we do have been is something that expected, all have to answer, so there all the specific strategies that you do know calling me while to make sure that everyone is participating is a thing I'm very keen on, and I'm trying to work a bit better on, now because making sure that everyone is answering you know like just with the calling, are they really going to answer, and forcing them to give whatever answer it is, I say it doesn't matter even it is a wrong answer, these are my answer, I don't really care, I think that I don't care, in here we're learning you're here for making mistakes, so you need to give it to me, if you don't give an answer you will get a consequence, they have to give me an answer right or wrong, but they have to give an answer which is not I don't know, so in that case will be classes speaking options so, you know, again recognising that we do have such as stretch in the ability of our kids because we're not setting, that's we do have kids, I know, I do have kids sometimes that they're right, they almost already know to lesson especially in Year 7, because in your, in primary, they might have done a lot of science, because if we got maybe 2-3 an added, that not that science at all, you know, and after you've got kids you know really understanding and mature about how to approach education, then they have high targets in their life, and pushing themselves so much, and other than that, for all other variety reasons for some they don't believe in themselves, they are not very able, to not have a family that can support them, the one can't understand them very well, whatever it is, so you have these, this gap between them increasing and increasing and increasing and increasing, so you know, the people in which do a confident and want to do well they tend to ask more clarification, and a type of questions which are related, or you might have the ones which are not very strong but their confidence that they do ask questions about, oh I didn't get this one, so, is two types of a situation so and it will be beautiful that both of them that, that was about building confidence and I don't think it's just the science, yes, it may be also about a little bit culturally science is perceived as difficult and trying to break that, break that point, yes it can be difficult but it doesn't matter, it doesn't really matter the point is that you that you try, it yeah framing it in a different way, but it is not a one day job.

R: Okay, so thank you so much for your time and interest to participate in the interview, I don't have any questions to ask but if you would like to add anything, I will be happy to hear.

T: Not really, thank you, I look forward to seeing your results.

R: Thank you, I will be happy to share them when I can.