Urban girls' engagement with science within lessons, class visits and family visits to science museums

Interactions of gender, social class and ethnicity

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Urban girls' engagement with science within lessons, class visits and family visits to science museums: Interactions of gender, social class and ethnicity

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Abstract

There are persistent gender inequalities in science participation, further stratified by social class and ethnicity. This study takes a sociological approach to examine how interacting social axes shape girls' engagement with science within lessons, class visits and family visits to science museums. The data were collected through interviews, focus groups and observations with the girls (n=15), their parents (n=10) and their science teachers (n=4) and analysed by drawing on Bourdieu's theory of social reproduction and Butler's theory of gender performativity.

The main contribution of this study is an in-depth understanding of the vital role that social contexts play in shaping girls' engagement with science. This study found that ethnicity complicated the influence of working class backgrounds, in that high parental aspirations and support for science positively shaped their identification with the subject and their aspirations. Yet, there was a gendered and ethnic aspect of science capital, which challenged how they recognised and deployed their limited resources. Engagement with science was produced when their resources and dispositions aligned with expectations of a particular social context. A change in a physical setting was not enough to open up opportunities for engagement, without also a shift in norms, values and recognition. Performances of heterofemininity were mostly in tension with engagement with science in the context of the science class. The girls who behaved well and worked quietly, performing restrained heterofemininity, risked invisibility. The celebrated ways of engaging with science required confident displays of knowledge, enacted through 'muscular intellect'. The family context provided different opportunities for the girls' engagement with science to the science class, but these were constrained by the challenges they encountered during their science museum visits.

Table of contents

List of figures

List of tables

Preface

My own educational and professional journey began in the area of science, leading among other posts, to working at a medical research laboratory at the local University of Ljubljana, Slovenia. While my area of pharmaceutical and biotechnological research was relatively gender-balanced, the computer science and engineering faculties down the road were almost exclusively male. For much of my growing up, I took for granted that the trajectories associated with physical sciences were somehow better suited to men. The idea of being one of the very few female students in an overwhelmingly male area was not particularly comfortable at the time. Similar ideas, I suspect, may have shaped the decisions and trajectories of other girls and women, who might have dismissed pursuing science altogether.

For decades, there have been attempts to attract a more diverse student population into post-compulsory science education and careers. Girls, in particular, have been the focus of many such initiatives. Yet despite the efforts, there appears to have been little change in the patterns of participation over time. This study draws on science education literature, sociological theory and the data from a year-long qualitative study to examine how interactions of gender, social class and ethnicity shaped engagement with science among the girls from lower socioeconomic and ethnically diverse backgrounds.

In this thesis, I address the following two research questions:

1. How do interactions of gender, social class and ethnicity shape girls' preliminary engagement with science?
2. How do interactions of gender, social class and ethnicity shape girls' engagement with science within lessons, class visits and family visits to science museums?

In **Chapter 1**, I introduce the issue of girls' engagement with science and present the rationale for this study. I draw together the evidence for persistent gender inequalities in science participation in the UK and internationally and discuss the ways these are further stratified by social class and ethnicity. I argue why it is important to continue working towards greater equality in science. I introduce the literature and theory on student engagement and outline the approach taken to examine the girls' engagement with science in this study. Finally, I discuss the literature on the opportunities available outside the classroom and highlight the value of studies including multiple social contexts and physical settings for understanding the complexity of diverse young people's engagement with science.

In **Chapter 2**, I outline the theoretical resources I draw upon in this study to unpack the girls' engagement with science. First, I discuss Pierre Bourdieu's theory of social reproduction, which is helpful for examining the role of social class and ethnicity nested within class. Bourdieu's main thesis proposes that social progress is determined by the dispositions one is socialised with ('habitus') and the cultural, social and economic resources possessed ('capital'), which have their value determined by the norms and expectations of a particular 'field'. Second, I discuss Judith Butler's theory of gender performativity, which is helpful for examining the role of gender and its interactions with social class and ethnicity. I outline how both theoretical frameworks have been usefully applied in education and science education research previously as well as why I consider them helpful for this study.

I then present the methodology and methods I employed to carry out this study in **Chapter 3**. Data collection was organised around a series of project activities, including class and family visits to two science museums. To address the research questions, I adopted a qualitative approach guided by the philosophical underpinnings of social constructionism. The key participants of this study were 15 girls from two science classes, recruited from schools in London and Manchester. In addition to the girls, I also collected the data from their parents (n=10) and their science teachers (n=4). The data collection methods included focus groups, interviews and observations with all the participants. The data were analysed through thematic and discursive analytical approaches. In this chapter, I also present the typology of the girls' engagement with science (as preliminary engagement with science and engagement with science in practice), which I then discuss through the two theoretical lenses in the subsequent four chapters.

In Chapters 4 to 7, I discuss the findings of this study. These chapters are organised by the theoretical approaches taken to analyse the data, the types of engagement with science discussed and the social contexts. In **Chapter 4**, I discuss the girls' preliminary engagement with science through a Bourdieusian lens. I focus on the role of the girls' past and present experiences at home and at school as well as the resources that they had available and were able to mobilise to their advantage. I discuss the role of social class in shaping the patterns of social reproduction and highlight that the girls' ethnic background and migration history importantly mediated classed attitudes and aspirations, including in relation to science. I argue that despite high aspirations, many of the girls had limited resources to support these. The resources they possessed were in some cases constrained by not being recognised or considered valuable and in turn, not mobilised for supporting their engagement with science.

In **Chapter 5**, I present a Bourdieusian analysis of engagement with science in practice during science lessons and class visits to the science museums. I argue that a change in physical setting did not disrupt the normative ways of doing science. The findings suggest that the expectations and recognition permeating the science classroom largely remained similar during the class visits to the science museum. I argue that the girls' engagement with science in practice was constrained by the tension between their behaviours and resources, along with the expectations within their lessons and museum visits. I suggest that strong engagement with science was enabled when the girls' behaviours and resources were aligned with the field. I conclude the chapter by examining the shifts in the field to raise and widen the girls' engagement with science.

In **Chapter 6**, I discuss the gender analysis of the data on the girls' engagement with science. I interrogate the girls' gendered discourses of science and how these shaped their construction of some aspects of science as not suitable ('intelligible', in Butler's sense) for the girls. I examine the strategies of how the girls resisted the dominant discourses in order to make identifying with science possible for themselves. I then argue that performances of femininity appeared only partially to enable the girls to engage with science within the context of the science class. I suggest that while hyper-heterofemininity sat in tension with engagement with science, restrained heterofemininity enabled better engagement with science, but risked invisibility. Authentic and recognised engagement with science, as perceived by the science teachers, was enacted through 'muscular intellect' and involved confident, visible and active displays of knowledge.

In **Chapter 7**, I discuss the girls' experiences and their engagement with science during family visits to science museums, drawing on Bourdieusian and Butlerian theories. I highlight that in the presence of multiple barriers, there were few opportunities for the families and girls to engage with science. The family context did, however, enable some different opportunities for the girls to do so, such as through performances of 'big sister' femininity and through leveraging school resources. These moments of engagement provided a useful insight into how engagement could be better facilitated within places like science museums. I conclude by discussing a case of one of the participating girls, for whom I noted the most significant shift in engagement with science between science lessons and science museum visits.

In the concluding **Chapter 8**, I summarise the findings of this study and highlight its key empirical and theoretical contributions. I discuss the implications arising from the findings and make recommendations for practice, consider the limitations of the study and suggest avenues for further research.

Chapter 1: Girls' engagement with science: Introduction

1.1 Introduction

This chapter provides an introduction to the thesis by setting out the rationale for the study on urban girls' engagement with science. I begin by discussing the literature on science participation and explore some of the key factors contributing to the gender inequalities that have been highlighted in previous studies. In particular, I focus on interests, attitudes, aspirations and identification with science. I then introduce the concept of student engagement with science that is central to the study presented in this thesis. Finally, I discuss the potential of informal science learning opportunities for raising and widening young people's engagement with science, specifically within science museums, and consider the value of taking a multi-contextual and multi-sited approach to studying engagement with science. I conclude the chapter by outlining the research questions I address in this study.

1.2 Participation figures and rationale for gender equality in science

Girls and women's participation in science education and employment

The participation of girls and women in science has improved significantly during the course of the last century (Harding, 1998). Women now occupy a diverse range of positions across all areas of science and have won multiple prestigious awards for their scientific discoveries (AAUW, 2010; Nobel Prize, n.d.). Yet, despite these improvements, entrenched inequalities still persist in terms of girls and women's participation in science education and employment. In this subsection, I provide a brief overview of participation figures. While the focus of this study is mostly on participation in and engagement with science (see section 1.4), I also draw on the literature that has examined participation in science, technology, engineering and mathematics (STEM) and science, engineering and technology (SET) areas, as these groupings have become popular in vocational and economic discourses (V. Wong, Dillon, & King, 2016). I recognise the differences between these groupings and while the figures cannot be directly comparable, I suggest that they nonetheless contribute to the overall picture of participation inequalities.

According to a WISE (2015b) report based on the data from the UK's Office for National Statistics, women make up only 13 per cent of all STEM workforce (including health occupations) in the UK. Participation figures vary significantly between different areas. While women represent 54 per cent of all health professionals[1], only 5.7 per cent of engineering professionals are female. Similar proportions have been reported across the Western world (AAUW, 2010; OECD, 2011), including in the most so-called 'gender equal' countries like Norway (Sinnes & Løken, 2014). Interestingly, the participation of women in STEM occupations is proportionally lower in the Western world (North America as well as Western and Central Europe) compared to other areas (Middle East, North Africa and Asia) (Yfactor, 2015), raising issues about the cultural influences on science participation.

Participation patterns are not stratified only by gender, but also by social class and ethnicity (Smith & Gorard, 2011). While science has been framed as white (see section 1.3), the participation data have indicated that in the UK, women from black and minority ethnic (BME) backgrounds enter into science, engineering and technology (SET) occupations (including health occupations) at higher rates than women from white backgrounds (Kirkup, Zalevski, Maruyama, & Batool, 2010). For instance, 8.2 per cent of all working BME women are employed in SET occupations in the UK, compared to only 5.1 per cent of all working white women. Participation of BME women in SET occupations has also been increasing at a faster rate in comparison to white women. Important differences exist within the grouping of

[1] According to the Office for National Statistics classification used in the report, 'health professionals' include medical practitioners, psychologists, pharmacists, ophthalmic opticians, dental practitioners, veterinarians, medical radiographers, podiatrists and health professionals not elsewhere classified. 'Health occupations' include health professionals and associate health professionals.

BME women, for not all ethnic minority women are represented in SET occupations at higher rates than white women. However, there appears to be limited statistical data available on specific ethnic backgrounds. A report by the Campaign for Science and Engineering (CaSE, 2014) has noted that figures for women from individual BME groups by SET occupations often fall below statistically reliable thresholds and following the Office for National Statistics' advice, these data can therefore not be used reliably. There is, thus, an incomplete understanding of how women from different BME ethnic groups are represented across SET occupations in the UK. There seems to be even less data available on the class origins of women who work in these occupations. However, studies with younger people have found that white working class girls, for instance, were the least likely to see science as 'for them' (Archer, Osborne, et al., 2013) and in comparison with their middle class peers, they were less likely to pursue higher education altogether (Reay, 2001a).

Gender differences in science participation are relatively minimal before the age of 16, when students take General Certificate of Secondary Education (GCSE) examinations (JCQ, 2015b). Since the introduction of the National Curriculum in 1989, it has been compulsory for the majority of students to study 'broad and balanced' science until the age of 16 (most state schools in England have to follow the National Curriculum). Prior to 1989, students could choose from three separate science subjects already at the age of 14. Under that system, girls tended to drop physics and boys tended to drop biology (Fairbrother & Dillon, 2009). The introduction of the National Curriculum was important in assuring that more girls studied science beyond the age of 14, although this did not have the anticipated impact on their post-16 participation in science education (P. Murphy & Whitelegg, 2006).

Approximately equal numbers of boys and girls take separate science GCSE subjects (biology, chemistry and physics) or 'triple' science (JCQ, 2015a). Triple science is the most comprehensive course of science available at this level and has been considered to be suitable only for high achieving students, i.e., those who achieve level 6 or above (Fairbrother & Dillon, 2009). This course has become the route of choice to post-16 science participation in many schools (Banner, Donnelly, Homer, & Ryder, 2010), although not taking triple science does not automatically exclude students from continuing to A level science subjects. Alternatively to triple science GCSEs, students can study for the examination of ‘core’ and ‘double’ science, which cover the three science subjects in less depth.

There are bigger differences in participation in GCSE science subjects along the lines of social class and ethnicity along with factors like a school’s geographic location and whether it is in an area of economic deprivation. For instance, schools with the most students on free school meals[2] (FSMs) are most likely to have the fewest entries for triple science (New Schools Network, 2015) and pupil premium students have been found to be less likely to take triple science GCSE (R. Allen, 2015). The Open Public Services Network (OPSN, 2015) has reported that the provision of triple science also varies significantly among local education authorities. Schools in more deprived areas enter proportionally fewer students for triple science GCSE and students’ opportunities are in some cases restricted by the lack of provision of the triple science course altogether. In North East Lincolnshire, for instance, half of the schools did not offer triple science GCSE and more than a third of schools in Knowsley, Slough, Kingston upon Hull and Newcastle did not enter any students for this course in 2013-2014 (OPSN, 2015). Triple science participation also varies by ethnic background. Just under a quarter (24.6 per cent) of white British students entered triple science GCSE in 2013, in comparison to 38.5 per cent of Indian, 48.4 per cent of Chinese students and 14.7 per cent of black Caribbean students (B. Wong, 2016). The data on GCSE level participation, therefore, indicate that while there is little overall gender difference at this stage, *some* girls may be underrepresented in the comprehensive science courses, with a particular concern relating to those eligible for FSMs or pupil premiums and those

[2] A free school meal (FSM) is a statutory benefit available to school-aged children from families with low income or who receive other qualifying benefits. FSM eligibility is commonly used in education research and governmental reports as an indicator of economic disadvantage.

from some ethnic minority backgrounds whose participation in triple science is particularly low.

The gender gap in science participation begins to widen at the A level stage. Participation in biology is higher for girls, whilst chemistry remains relatively gender balanced and a significant gender gap appears in physics in favour of boys (Institute of Physics, 2012b; JCQ, 2015b). Only one fifth of students taking physics A level are female and the percentage has remained relatively stagnant over the last 20 years (Institute of Physics, 2012b). It is also important to consider that at A level, students study only three, occasionally four subjects, meaning that science subjects compete with a broad range of other subjects. There are no compulsory subjects at A level in England, unlike in many other countries (Hodgen, Pepper, Sturman, & Ruddock, 2010).

Lower participation of female students in some science subjects is not due to their lower attainment. Girls tend to outperform or are equal to boys in GCSE exams, including in most science subjects (DfE, 2016; JCQ, 2015b). Student attainment, however, varies across social class and ethnicity. Students from lower socioeconomic and some ethnic minority backgrounds tend to achieve lower grades at GCSE exams, which has implications for their A level studies (although, as I discuss later in this chapter, this is clearly not the only reason for stratified participation patterns in science). The data have shown attainment gaps for students eligible for FSMs (DfE, 2014, 2016; Gorard & See, 2009). In 2015, for instance, only 33.1 per cent of students eligible for FSMs obtained 5+ A*-C GCSEs, including English and mathematics, in comparison with 60.9 per cent of all other students. Socioeconomic background has been found to have more effect on the attainment of some ethnic groups than others. Black Caribbean and white British students tend to fall furthest behind in attaining 5+ A*-C GCSEs, including English and mathematics, when they are eligible for FSMs, in comparison to other ethnic groups (DfE, 2016). In the report on chemistry and physics participation among ethnic minority students in England and Wales, Elias, Jones, & McWhinnie (2006) have argued that many students from Caribbean, Pakistani and Bangladeshi backgrounds 'fall at the first hurdle' (p. iii), suggesting that they fail to achieve the attainment level at GCSE to be able to continue with selected A level science subjects.

The gaps reported at the A level stage carry on into higher education. The relatively low participation of girls in physical and engineering degrees, for instance, has been, logically, associated with low number of girls taking physics at A level (Silim & Crosse, 2014). There is a clear gender imbalance across a range of university science courses. WISE (2015b) has reported that female students represent the minority in engineering and technology (14 per cent), computer science (17 per cent) and architecture, building and planning (30 per cent) degrees, while they dominate degrees achieved in subjects allied to medicine (82 per cent), veterinary science (78 per cent) and agriculture and related subjects (64 per cent). Most of the male-dominated courses tend to be associated with physical sciences and technology, while most of the female-dominated courses are more likely to be aligned with nurture and care, thus fitting with traditional gender attributes associated with masculinity and femininity (Butler, 1999; Harding, 1986). The reasons for stratified science participation patterns and the so-called 'leaky pipeline' (Blickenstaff, 2005) of science education, whereby women drop out at every stage, are multidimensional and shaped by the interacting social axes.

Why pursue greater gender equality in science?

It has been widely agreed that greater gender equality in science is an important goal to pursue and I concur. The following statement from the United Nations Educational, Scientific and Cultural Organization (UNESCO) captures this argument well.

> Gender equality in STEM is not only a matter of fairness, or a basic human right. In fact, the untapped potential of brilliant girls and women who might be interested in STEM but choose not to pursue degrees or careers in these fields because of the various obstacles they may face, represents an important lost opportunity, both for women themselves as well as for the society as a whole. Gender equality should

> therefore be considered as a crucial means to promote scientific and technological excellence. (UNESCO, n.d.)

Ensuring greater gender equality in science is first and foremost a social and moral imperative. It is important to enable all young people equitable education and employment opportunities, as a way of promoting and working towards greater social justice.

Further to the social justice rationale, many practical reasons have been outlined in the literature as to why it is important to work towards encouraging more girls and women into science. Three of the most common discourses that have driven the policy agenda for encouraging more girls into science are: (i) more women could help meet the perceived demands for a future scientific workforce; (ii) more diverse scientific workforce could contribute to more and better scientific advances; and (iii) more equitable opportunities could contribute to better public scientific literacy for all people, whether they pursue science-related occupations or not. These rationales are not specific to girls/women, for they also apply to other social groups who tend to be underrepresented in science, such as boys/men from working class and some ethnic minority backgrounds. I now outline each of the three rationales in turn.

First, one of the most visible rationales for why more should be done to recruit girls into science is that this could address the widely accepted 'crisis'[3] in science participation (Silim & Crosse, 2014; Zecharia, Cocgrave, Thomas, & Jone, 2014). The 'crisis' discourse refers to the insufficient numbers of young people entering into scientific professions to meet the growing demands for skilled scientific workforce and the impact this might have for the economy. The quote below from the Confederation of Business Industry report illustrates this debate.

[3] The notion of 'crisis' is not unambiguous. Many have argued that the predictions based on previous supply and demand patterns lack reliability and might have been exaggerated (House of Lords, 2012). Osborne & Dillon (2008) have speculated that the 'crisis' debate could have been at least partially influenced by the scientific community itself, which has reaped benefits from the governmental investment in research, development and training in science.

> Science, engineering and technology are the foundation for innovation and technological advance, and are traditional strengths of the UK economy. But skills shortages will threaten businesses capacity for growth unless action is taken now. (CBI, 2010, p. 2)

There are two parts to this argument. Firstly, scientific and technological progress is seen as intrinsically linked to the national economy. Secondly, there is an assumption that there will be a shortage of scientific skills unless something is done to recruit more people into science. Science has been widely associated with economic growth and has therefore been seen as critical for the future competitiveness of the UK (HMT, 2004; Sainsbury, 2007). In the light of this argument, the estimated predictions about the future of supply and demand regarding a scientific workforce have raised concerns across the public and private sector. In his report for the Department for Business, Innovation and Skills, Heseltine (2012) cautioned that it was estimated that there would be a requirement for more than 100,000 STEM graduates per year for the period between 2012 and 2020, and that this would not be met by newly graduating STEM students who amounted to only about 90,000 per year, thus suggesting a shortage of 10,000 STEM students annually. Concerns about the future supply of STEM graduates have been echoed across Europe. Reports have highlighted that in comparison with the US and Japan, the European Union lags behind in terms of the numbers of science researchers per overall numbers of citizens, with implications for future economic competitiveness (Convert, 2005; European Commission, 2004; Haas, 2005). Further, according to a survey conducted by the CBI (2011), many UK employers were already then experiencing difficulties in recruiting staff with appropriate STEM skills and qualifications.

The concerns about skills shortages, however, do not relate to all STEM industries and all geographical locations (Osborne & Dillon, 2008; Smith, 2010; Smith & Gorard, 2011; UKCES, 2013). They are relevant for a more specific recruitment of highly skilled workers in in-demand areas, such as for instance, the biopharmaceutical industry and engineering (ABPI, 2015; DIUS, 2009; RAENG, 2012; Smith, 2010). Encouraging more girls into the key areas has been seen as a way of addressing the existing and predicted skills shortages. Girls have been seen as an untapped potential or a 'lost opportunity' (see UNESCO's quote above) and their underutilisation has therefore been seen as contributing to diminished national productivity (Ramirez & Wotipka, 2001).

Encouraging girls' participation in science could contribute to more than merely filling the skills shortage gaps. The second rationale for encouraging more girls into science is the potential for different and better scientific advances. Harding (1998) has argued that a shift towards a more equal participation of men and women in science has already benefited the cause of women, in general, as well as the sciences, such as for instance in the area of women's health. It would be reasonable to assume that further success in encouraging more girls into science would continue to benefit this area. Widening participation could influence the culture of science and scientific practice. More women could contribute to more diverse viewpoints in the practice and teaching of science (Harding, 1989, 1998; Longino, 1990; Sinnes & Løken, 2014). Historical accounts have convincingly demonstrated that more women entering scientific professions has already contributed to important new insights and better consideration of the diversity within the population (Harding, 1992, 1998). Finally, the overall greater workplace diversity in terms of gender as well as other social axes, including ethnicity, social class, disability and sexual orientation, has been found to increase creativity and chances for innovation (Page, 2008).

Women's potential contribution to scientific progress and practice has value beyond economic prosperity and growth, which I highlighted in the first rationale. Many areas of science, such as the so-called 'blue skies' or basic scientific research, do not necessarily contribute to immediate financial benefits and often have little commercial value in themselves (Schofer, Ramirez, & Meyer, 2000). Regardless of the economic implications, it has been widely agreed that scientific research is valuable for improving the well-being of people and for helping find solutions for a more sustainable future. Science has become institutionalised as an important activity yielding social progress, contributing not only to scientific achievements, but also to progressive social agendas and more sustainable and healthier lives (Schofer et al., 2000).

The third rationale for greater gender equality in science is that more equitable opportunities could contribute to better public scientific literacy for all (Osborne, 2010; Reiss, 2007). Scientific literacy has been defined as understanding how science works and has been considered vital for encouraging active citizenship (Durant, 1994), whether one pursues science-related trajectories professionally or not. Being scientifically literate plays an important role in making informed everyday decisions, such as about health or energy use, thus possibly accruing personal and economic benefits. Being scientifically literate could also help people in critically assessing the risks associated with science. The public association of science with dangers like nuclear disasters and medical catastrophes has taken its toll on public trust in science. It is therefore vital that people have some understanding about how science works (Beck, 1992; Ipsos MORI, 2014; Irwin & Wynne, 1996; Michael, 2006; S. Miller, 2001). This is particularly important, because trust plays an important role in people's acceptance of new technologies, such as in medicine (Lang & Hallman, 2005; Siegrist, 2000; Wynne, 2005). If people are to understand and benefit from scientific advances, they must feel empowered to distinguish between science and pseudo-science (Bickerstaff, Lorenzoni, Jones, & Pidgeon, 2010; Rocard, 2007; Ziman, 2000). Finally, science is also an important part of cultural life. Osborne (2007), for instance, has argued that people who lack scientific literacy are 'culturally deprived unable to participate fully in the discourse of daily life' (p. 178).

Initiatives to encourage more girls into science

The perceived importance of increasing girls' participation in science is evident from the myriad of initiatives that have been carried out over the past decades, both in the UK and internationally. In the UK, some of the most visible organisations and projects working towards engaging girls and diverse young people with science have included a campaign to promote women in science, technology and engineering (WISE, 2014, 2015a), Science Grrl (Zecharia et al., 2014), Code First:

Girls, STEMettes and Let’s TWIST (Train Women in Science and Technology) (Williams, Turrell, & Wall, 2002), to name a few. At the European Union level, initiatives have included the Gender Awareness Participation Process (GAPP, 2009), Towards Women in Science & Technology (TWIST, n.d.), Science: It’s a girl thing! (European Commission, 2015) and Hypatia (Hypatia, n.d.). These initiatives have been very diverse, including mentorship schemes, activities for challenging stereotypes associated with STEM careers, training teachers and working with informal science learning environments in more gender-inclusive ways.

Despite decades of initiatives aimed at increasing and diversifying participation in science, there appears to be little evidence about the impact that these programmes have had. In the UK, many initiatives have not been evaluated, at least not in any great depth (Wynarczyk & Hale, 2010). The data on the overall science participation figures have suggested that the patterns have proven to be difficult to change (Smith, 2011b; The Royal Society, 2008). A meta-study of three decades of UK initiatives aimed at encouraging girls and women into science education and careers has gloomily concluded that these initiatives ultimately had little or no effect (Phipps, 2008). It has been suggested that the relatively low success of gender-focused initiatives may be associated with the overwhelming concentration on the ‘cosmetic character’ of science (Sinnes & Løken, 2014, p. 361), such as girls’ attitudes and interests towards a pre-defined science, instead of also challenging the broader structural issues permeating science education. Sinnes & Løken (2014) have convincingly argued that it is not sufficient to challenge the stereotypes about science that some young people might hold, particularly as many of these so-called ‘stereotypes’, like that science working environments are more welcoming to men than women, seem to be at least partially true (Carlone & Johnson, 2007).

Harding (1998) has proposed that there is a need to move away from asking what is ‘wrong’ with girls for not participating in science and not realising how valuable and exciting science is, to what might be ‘wrong’ with science for failing to be inclusive and attractive to a greater diversity of people. Sinnes & Løken (2014) have also cautioned against taking overly feminising approaches to science initiatives like making science exceedingly 'girl-friendly'. Such programmes and activities have risked treating girls as a homogenous group and stereotyping what all girls were meant to like, hence making it difficult for diverse girls to engage with science. In the authors' words, 'adjusting science subjects to match perceived typical girls and boys' interests risks being ineffective, as it contributes to the imposition of stereotyped gender identity formation, thereby also imposing the gender differences that these adjustments were intended to overcome' (Sinnes & Løken, 2014, p. 343). The findings and arguments from the literature highlight the need for further research on understanding the impact of various initiatives.

1.3 What influences gender inequalities in science?

In this section, I discuss the arguments from the wider literature about what are some of the key factors contributing to stratified patterns in science participation. I argue that the construction of science as rational, objective and thus masculine, which has permeated mainstream science education, has made science difficult to engage with for some students. I then draw together findings from previous studies on interests, attitudes, aspirations and identification with science, which provide insights into the reasons for persistent gender inequalities. While I put gender at the forefront, I also consider the interactions with social class and ethnicity, to unpack the diversity within the category of girls.

Science education privileges the norms and values of science

Science education has tended to reflect the norms and values of science that permeate the scientific community (Carlone, 2004; Osborne, 2007). The reason for this is partly due to its focus being on producing future scientific workforce rather than a scientifically literate public (Osborne & Dillon, 2008; Osborne, Simon, & Collins, 2003). Brickhouse (2001) has argued that such an approach more closely resembles 'training' rather than 'education'. Further, Osborne & Collins (2001) have critiqued the mainstream science education for being 'education *for* science rather than education *about* science' (p. 442, my emphasis). Science teachers are often pressured into preparing students for further studies and careers in science (Fensham, 2008; Osborne & Dillon, 2008), which shapes the way science is taught and what is considered to be a 'good' science education. It is not surprising that if the goal of science education is to prepare students for careers in science, the way science is taught aligns with the scientific communities' norms and values, which are historically, socially and politically situated.

It has been widely accepted that science is not neutral and it does not transcend culture (Brickhouse, 1994; Calabrese Barton, 2000; Harding, 1998; Keller, 1985; Lemke, 1990). In the words of Zacharia & Calabrese Barton (2004), 'scientific knowledge is a human made explanation of how the world works and therefore scientific knowledge is embedded with human values and characteristics' (p. 203). While many scientific methods might be perfectly valid and produce perfectly legitimate scientific knowledge, it is important to consider who is asking the questions in science, who has an authority to decide what 'counts' as science and what values permeate scientific practices (Medin & Bang, 2014).

Science has been primarily constructed as white, masculine and middle class (Aikenhead, 1996; Harding, 1998). Western science has historically largely been produced with little contribution from women and people from non-Western cultures (or their contributions failed to be recognised). Science has traditionally been associated with rationality and objectivity, which have traditionally been considered masculine characteristics (Brickhouse, 2001; Harding, 1986; Keller, 1985) and reason/masculinity has tended to be valued higher than unreason/ femininity (Harding, 1998; Lloyd, 1993). Walkerdine (1989) has noted that the rational self is 'a profoundly masculine one from which the woman was excluded' (p. 269), thus suggesting that it is more difficult for women to be included in the rational and objective domain of science than it is for men. I argue that such a framing of science inevitably shapes how inclusive science education is for female students.

Many within science education now recognise that the way science is taught reproduces classed, gendered, ethnic and other divides between who does and does not do science. Research has suggested that science education has tended to privilege students from social groups who have traditionally represented the majority of the scientific workforce, i.e., white middle class men, who constitute the so-called 'culture of power' (Calabrese Barton & Yang, 2000; Carlone, 2004; Lemke, 2001). Students who do not easily align with the dominant culture of science find it more difficult to participate successfully in science education (Brickhouse, 2001; Calabrese Barton et al., 2012; Carlone, 2003; Carlone, Scott, & Lowder, 2014; Lemke, 1990). The prevalent association of science with masculinity has made it difficult to engage with for many girls. As Lemke (2001, p. 300) has argued, science might be too 'aggressively masculine', too 'narrowly rationalistic' and too 'technicist, abstract, and formalist' to sit well with many girls and women.

By privileging some knowledge, experiences and behaviours over others, science education has been seen as providing limited opportunities for engaging diverse young people with science. Studies have suggested that girls and students from lower socioeconomic and some ethnic minority backgrounds have often faced challenges in being positioned as 'good' science students and being recognised by their teachers and peers as such (Aschbacher, Li, & Roth, 2010; Basu, Calabrese Barton, & Tan, 2011; Brickhouse, 2001; Brickhouse & Potter, 2001; Carlone, 2004; Lemke, 1990; Osborne et al., 2003). As Carlone (2004) has pointed out, the science identities that are promoted in the science classroom may not be socially available, possible, or desirable to all students. The issues of how science is dominantly constructed and what is valued and recognised in science education play an important role in young people's engagement with it. In Lemke's (2001) words, '[w]e cannot afford to continue to believe that our doors are wide open, that admission is equally free for all, that the only price we ask [from students] is hard work and logical thinking' (p. 312).

Girls' interests, attitudes, aspirations and identification with science

The reasons for stratified patterns in science participation have been explored through a number of different factors, most pertinent for this study including interests, attitudes, aspirations and identification with science. Research has suggested that girls generally tend to have less positive attitudes towards science and are less interested in it than boys (Archer, Osborne, et al., 2013; Brotman & Moore, 2008; Institute of Physics, 2012a; C. Murphy & Beggs, 2005; Osborne et al., 2003; Sjøberg & Schreiner, 2010). For instance, the ASPIRES study in the UK found that fewer girls than boys reported being keen on science at the age of 10-11 (37 per cent versus 63 per cent). The authors also reported differences among girls, stating that amidst the girls who were keen on science, the overwhelming majority were middle class (Archer, DeWitt, et al., 2013).

While interests and attitudes are clearly important, they alone may not be able to explain the persistent stratification patterns into science participation. Being interested and liking science do not necessarily translate in aspiring to become a scientist or work in science. The ASPIRES study reported that while a large proportion of young people said that they liked and valued science (around three quarters of young people aged 11 to 14 said that they learnt interesting things in science and that they valued scientists for making a difference in the world), far fewer said that they would like to become scientists in the future (Archer, Osborne, et al., 2013). Interests and attitudes may therefore be a useful starting point, but they are not sufficient for examining engagement with science (Archer et al., 2010; Hidi & Renninger, 2006; E. W. Jenkins & Nelson, 2005).

The concepts of aspiration and identification with science have offered an additional way for understanding the inequalities in science participation. It has been argued that girls are less likely to aspire to careers in science than boys. Among 12-13 year old students, for instance, 18 per cent of boys and 12 per cent of girls aspired to become scientists. Girls were more likely to hold aspirations associated with arts-related and caring jobs, thus reflecting traditional gender choices and roles. Students who were the least likely to see science as being for them were white working class girls, and science-related aspirations were particularly low among girls who defined themselves as ‘girly’ or highly feminine (Archer, Osborne, et al., 2013). These findings further highlight the need for an approach to student engagement with science that takes into account that differences exist both between girls and boys and among girls themselves.

The concept of identification with science, also discussed in terms of a sense of belonging, has been particularly useful when studying young people's engagement with it. There has been a wide agreement among science education scholars that identity development is central to learning and participating in science (Brickhouse, 2001; Brickhouse, Lowery, & Schultz, 2000; Calabrese Barton & Tan, 2010). To engage with science, students must develop identities that are compatible with scientific ones. Calabrese Barton & Tan (2010) have argued that 'students who aspire for scientific competence while not desiring to take on aspects of the identities associated with membership in school science communities often face difficulties and even school failure' (p. 194). When students struggle to do so, this might result in so-called 'identity conflicts' between one's identity performance and required identity performance in science, potentially leading to disengagement (Lemke, 2001, p. 307). As students' science identities are often negotiated within the science classrooms, these are clearly not inclusive to all students, given the narrow opportunities available within science education that I discussed above.

To investigate identification with science, studies have examined young people's perceptions of 'science people'. 'Science people' have been discussed in terms of behaviours, academic achievements and social axes. Students have predominantly constructed 'science people' as being clever or 'geeky', which has been associated with masculinity and being middle class (Archer et al., 2010; Harding, 1986). Because of these associations, a sustainable science identity tends to be more difficult to achieve and manage for girls than it is for boys (Archer, DeWitt, et al., 2013; Carlone & Johnson, 2007; Ong, 2005). Being a (clever, geeky) 'science person' has been associated with socially undesirable labels like 'boffin', associated with an eccentric scientist with wild hair, often an older white middle age man (stereotypically, like Albert Einstein). This term has derogatory connotations and it has been argued to be particularly undesirable for girls (Francis, 2009; Mendick & Francis, 2012). Identifying with science has been contended as being particularly challenging for girls from backgrounds not usually associated with high academic achievement, such as working class and some ethnic minority girls (Archer et al., 2010).

The dominant framing of science and 'science people' might make science off-putting for girls who prefer to invest in performing more conventional feminine identities (Danielsson, 2011; Gonsalves, 2014; Walker, 2001). Studies have found that for many science-keen girls, engagement with science requires careful crafting of performances of femininity to balance the masculine connotations of science. Science has been framed by many of the girls and their parents as 'non-nurturing' and therefore in tension with girls who strived to be 'normal', 'caring' and 'girly' (Archer et al., 2010). In some instances, girls reported balancing their interest in science with extensive involvement with typically feminine pursuits, such as fashion, but such balancing acts were not easy. The precarious position of a 'feminine scientist', as the authors have labelled it, was largely available to and taken up by girls from middle class backgrounds (Archer et al., 2012a).

Developing a science identity has been argued as being more difficult for some girls than others. For instance, the narrow discursive space has afforded little opportunity for girls from some ethnic and class backgrounds to negotiate their positions in science (Brickhouse et al., 2000; Calabrese Barton et al., 2012; B. Wong, 2012). When exploring girls' engagement with science, it is therefore not enough to take into account the fact that these are girls, for it is important also to consider 'what kind of girls they are' (Brickhouse et al., 2000, p. 457). Or in line with the theoretical framework I use in this study (Butler, 1999, see Chapter 2), it is salient to consider how these girls perform gender and how their performances are mediated by other social axes. Malone & Barabino (2009), for instance, have argued that race presented an 'additional burden' for the African American female participants in their study when negotiating science identities. Atwater (2000) has rightfully reminded the science education community that the disadvantages are multiple and intersecting, thus a white female should not present the norm for gender issues in science education research at the expense of insufficiently considering the role of other social axes.

Identification with science is influenced by whether one is recognised as scientific, or not, by other people, such as teachers, peers and parents. Carlone & Johnson (2007), who have coined the term 'science identity', have argued that science identity depends on self-identification and recognition from others. In the science education literature, most studies have focused on how students are recognised by their science teachers. The students who struggled to be recognised as 'scientific' or 'good' science students encountered challenges in relation to their self-concept in science. Previous studies have usefully discussed the role of teacher recognition for a number of case study examples and have highlighted that despite exhibiting interest in and enjoyment of science, some of the girls who did not behave 'properly' risked not being recognised by their teachers as 'scientific'.

Brickhouse et al. (2000), for instance, have illustrated the challenges of not being recognised as a 'science person' by drawing on the experiences of an African American student they called 'Tanisha'. Tanisha was a science-keen student, who collected rocks for a hobby and articulated having an interest in science. She was an energetic participant in the classroom, but often got bored when her science lessons became slow-paced and she visibly showed her boredom. Tanisha was often loud and assertive during science lessons. Her behaviour, regarded as typical of 'loud black girls' (Fordham, 1993), made it challenging for her to be recognised as a 'good' science student by her teacher. Her teacher did not see her as someone who was likely to continue with science, which had implications for her progression through secondary schooling. Tanisha's story resonates with many other cases reported in the literature. Girls who did not fit with the expected classroom behaviours, for either being too loud, too quiet or too assertive (Carlone, Johnson, & Scott, 2015; Carlone et al., 2014) risked negative status attribution, which appeared to have compromised their future engagement with science.

The issue of recognition is particularly troubling when teachers' criteria for who gets to be recognised as 'scientific' appear to bear little relation to actual engagement with science, but rather reflects the educational pursuit of behavioural compliance. For instance, one science teacher in a study conducted by Carlone et al.

(2014) remarked that he mostly valued compliance and 'good' behaviour, which the authors commented had 'nearly nothing to do with engaging in scientific practices, thinking scientifically or problem-solving' (p. 853). Yet, these criteria appeared to have determined which students were recognised as 'scientific' and which were not and in some cases, which students were recommended to progress to more demanding science classes that opened doors to further studies. Others have found that behaviours associated with compliance, passivity and submissiveness might become more valued than girls' science-related interests (Tan, Calabrese Barton, Kang, & O'Neill, 2013). It is therefore evident that for girls whose behaviour does not meet expectations, the opportunities to gain positive recognition in a mainstream science classroom are narrow and it is difficult for them to engage sustainably with science in ways that are recognised and celebrated by the school (Brickhouse & Potter, 2001; J. Thompson, 2014; Varelas, Kane, & Wylie, 2011).

The challenges regarding identification with science and recognition as 'scientific' are not limited to compulsory science education, for they also extend to women's professional lives. Carlone & Johnson (2007) examined the experiences of 15 'successful women of color' in the US who were at the time of their study pursuing a postgraduate degree or working in a science job. A quote from an African American student gives an illustrative insight into the experiences of some of these women. 'Alethia' reflected on her feelings of disconnection while working in a science laboratory as a molecular biology research student, 'I get the feeling I do when I walk through somebody's house with shoes on. Like I'm in somebody else's home and I'm improperly walking, when I'm in science' (quoted in Carlone & Johnson, 2007, p. 1203). Carlone & Johnson (2007) have argued on the basis of these women's experiences that it appears to be 'much easier to get recognized as a scientist if your ways of talking, looking, acting, and interacting align with historical and prototypical notions of scientist' (p. 1207). They have added that the notion of scientist seems to be particularly non-inclusive to 'women of color'. Studies have also suggested that when students were not recognised and valued, or when they struggled to negotiate their identities within science, this had negative implications for their long-term engagement with the subject (Brickhouse et al., 2000; Carlone, 2004).

1.4 Student engagement with science

This section outlines the theoretical approaches to student engagement that I draw upon in this study. In Chapter 2, I present the theories I drew upon to interrogate how engagement was shaped by multiple interacting social axes. The term 'engagement' has been widely used in academic, policy and practice discourses across the education and science education literature. Particularly relevant for this study are the discourses about the need to *raise* young people's engagement with science, such as addressing the perceived 'crisis' in science participation. In their report on the state of science education in Europe, Osborne & Dillon (2008) have urged that 'the emphasis in science education before 14 should be on engaging students with science and scientific phenomena' (p. 9). In the science education literature, engagement with science has been associated with better learning and improved academic attainment, as well as with an increased long-term participation in science (Friedman & Ginsburg, 2013; Hampden-Thompson & Bennett, 2013; Osborne & Dillon, 2008). Despite the seemingly vital need for engagement with science, the term has rarely been defined explicitly or it has been defined in a range of vague ways. For instance, engagement with science has been conceptualised as 'the quality of the relationship between an individual and an activity' (F. S. Azevedo, 2006, p. 60) and 'the intensity and emotional quality of students' involvement' (Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey, 2010, p. 3). It appears to be taken for granted that everyone understands and agrees about what student engagement with science entails, but the diverse use and application of the concept suggest that this might not be the case.

Student engagement with science should not be confused with public engagement with science, which has been widely discussed particularly in the area of science communication and has to some extent been taken up by science education as well. While student engagement with science focuses on students' experiences and connections with science (see below for further elaboration), public engagement focuses on two-way interactions between the members of public and the members of the scientific community. The Center for Public Engagement with Science and Technology has defined public engagement with science as ‘intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public’ (AAAS, n.d.). The notion of student engagement with science that I work with in this study, however, has no relation to working directly with the scientific community and does not involve any aspects of ‘mutual learning’.

Given the vague framing of student engagement with science in science education literature, I draw on ideas that relate to more general ‘student engagement’, meaning that with school rather than a particular subject. These ideas have been usefully compiled in the *Handbook of Research on Student Engagement* (Christenson, Reschly, & Wylie, 2012) and outlined in seminal papers by Fredricks, Blumenfeld, & Paris (2004) as well as Lawson & Lawson (2013). Furrer & Skinner (2003) have provided a useful starting definition of student engagement as ‘active, goal-directed, flexible, constructive, persistent, focused interactions with the social and physical environments’ (p. 149). The student engagement literature has also focused on the quality of students’ connections and their involvement with schooling (Skinner, Kindermann, & Furrer, 2009). The work on these aspects has largely focused on dropout prevention, the premise being that if students are engaged with school they are more likely to learn better, achieve more and increase their chances of completing schooling. Particularly useful has been the socio-psychological student engagement model proposed by Fredricks et al. (2004) that has underpinned many previous student engagement studies. The authors have outlined three dimensions of student engagement: (i) cognitive engagement, including persistence, willingness, motivation and psychological investment to learn; (ii) affective/emotional engagement, including attitudes, interest, sense of belonging and identification; and (iii) behavioural engagement, including participation in activities.

The literature on student engagement has informed several previous science education studies, which have either used one of the established student engagement frameworks (e.g., Hampden-Thompson & Bennett, 2013 used Fredricks et al.'s model of student engagement) or have been carried out in ways that I suggest resonate with the student engagement models. Student engagement with science has been researched through a range of different factors (or 'indicators' of engagement), some of which I discussed earlier in this chapter. Studies in science education have focused on researching student engagement with science through students' interest in and attitudes to science (Ainley & Ainley, 2011; Dabney, Tai, & Scott, 2016; Sjøberg & Schreiner, 2010), identification with science (Archer et al., 2012b; Calabrese Barton et al., 2012; E. W. Jenkins & Nelson, 2005; B. Wong, 2012) and participation in science-related activities (R. Azevedo, 2015; Barriault & Pearson, 2010; Sinatra, Heddy, & Lombardi, 2015). While I agree with Crick (2012) that the 'starting point of engagement is interest in something' (p. 682), I maintain that in line with the above discussion on recent empirical findings (e.g., from the ASPIRES study), interest and attitudes may not necessarily be able to explain inequalities in science participation. Calabrese Barton & Brickhouse (2006) have usefully proposed that engagement with science goes beyond knowing about and being interested in science, for it also involves an active involvement in it. In fact, they have perceived engagement with science to be a more valuable factor for understanding what influences young people's participation in the post-compulsory science education than the more conventional concept of achievement.

Student engagement literature has usefully distinguished between 'student engagement dispositions' and 'acts of engagement' (Lawson & Lawson, 2013), which I have drawn on to outline the two 'types' of engagement with science in this study. The former refers to students' tendency to engage, which encompassed factors, such as interest, sense of belonging, identification and aspirations. The latter refers to engagement that happens 'in-the-moment', in practice or during an activity. Student engagement dispositions and acts of engagement are part of a dynamic process, whereby the former (in the presence of opportunities) are manifested in the acts of engagement that are evident in practice (Lawson & Lawson, 2013). In this study, I work with both of these aspects of student engagement. However, for the purpose of clarity, I use the term 'preliminary engagement' rather than engagement dispositions. This is in order to avoid conceptual confusion, as the notion of 'socialised dispositions' is at the heart of Bourdieu's theory of social reproduction, which I use to analyse my data (see Chapter 2 for further elaboration of this theory).

In this study, I am particularly interested in what facilitates and constrains engagement with science, especially in relation to the interacting social axes and opportunities available to the girls within different social contexts and physical settings. The student engagement literature has distinguished between indicators, facilitators and outcomes of engagement (Sinclair, Christenson, Lehr, & Anderson, 2003; Skinner & Pitzer, 2012). Indicators are markers of engagement within the construct (what is or 'counts' as engagement), such as a sense of belonging or energy involved when participating in a particular activity. Facilitators are explanatory factors that are external to the construct and which influence engagement, such as family attitudes or socioeconomic background. Outcomes are the results that engagement produces, such as attainment. Lawson & Lawson (2013) have also considered a category of sociocultural indicators of engagement, which appears helpful for investigating engagement with science among young people who tend to be marginalised in traditional science classrooms and who might struggle relating to science. They have proposed that it is important to consider the degree to which students experience support for their socio-cultural and personal identities while participating in an activity, the emotions students experience when an activity has personal significance for them and the extent to which a particular task, activity, or setting connects with their prior knowledge and experience.

Scholars have highlighted that distinguishing between indicators, facilitators and outcomes of engagement is not always straightforward. An outcome of engagement may, for instance, simultaneously play the role of a facilitator for further engagement. To give an example of this, research has found that there was a correlation between students liking science and their attainment; students who reported liking science more had higher attainment. However, it was difficult to establish whether liking science led to better attainment or whether high attainment led to students liking science more (Friedman & Ginsburg, 2013). It is possible that attainment is both a facilitator and an outcome of engagement with science, which is aligned with the notion that engagement is a dynamic and cyclical process (Lawson & Lawson, 2013).

What is science?

Finally, given my focus on student engagement *with science*, it is important to spell out what I consider science to entail. I began with the Oxford English Dictionary (2013) definition of science, which provided a useful starting point. Science is defined in the dictionary as 'the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment'. The dictionary definition is relatively similar to how science has been framed by organisations like the Science Council (n.d.), which has defined science as 'the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence'. These definitions are very broad, yet seem to be difficult to operationalise in practice, such as when considering whether particular activities or conversations can constitute science, or not, and from whose perspective.

I agree with previously raised concerns that despite many elaborate definitions of science, it may not be straightforward to label what science entails in practice. Ziman (2000) has noted that science is too diverse to be captured in full by any single definition and has suggested that most people tend to recognise it when they come across it. The ambiguity of what science entails and what people think of as science is evident from the diverse ways of defining it, including among the scientific community itself (Ziman, 1991). Public polls have suggested that most people equate science with school subjects, seeing it as an umbrella term for physics, chemistry and biology (Ipsos MORI, 2014). I consider it important to attend to various possible understandings of what science is and what it means to engage with it, for I argue that this may have shaped how the girls related to, identified with and aspired to science.

What science entails relates to what is recognised by a scientific community (Reiss, 2004), as well as what passes as science by science curricula and teachers/examiners who mark students' science work (Reiss, 2015). It has also been proposed that instead of asking 'what is science?', it is worthwhile to consider the question '*when* is science'. This approach has been used to highlight that a person's meaning for the word 'science' might develop from their participation in various practices and that this also has implications for how a person is recognised in relation to science (Zimmerman, 2012). Similarly to Reiss, Zimmerman (2012) has argued that it is important to consider how the systems and people, such as a science teacher, might reinforce the normative views of what science entails and what falls outside its domain.

In this study, I started with the dictionary definition presented above and considered any reference to the natural and some physical/manufactured world as potentially constituting engagement with science. I considered a broad and plural definition of science in an attempt not to exclude any activities, experiences and knowledge as falling outside the domain of science. I also considered how this study's participants themselves constructed science, taking into account that people coming from different social backgrounds might have different views on what it entails (Medin & Bang, 2014). Nasir & Hand (2008) have proposed a useful way of thinking about engagement with a particular subject or a domain, seeing it as related to 'the notions of the self that one constructs in relationship with others in particular social contexts' (p. 145). I suggest that this broadens the ideas of what engagement with science entails, to include activities that may *contribute* to relationships with science. In Chapter 3, I further explain how I operationalised engagement with science in this study and give examples of what I coded as representing this in the data I collected.

1.5 Informal science learning environments

This study examines the girls' engagement with science across school and science museum settings. The rationale is to examine whether and how out of school opportunities may be able to support the urban girls' engagement with science better in comparison to school. In section 1.3, I argued that formal science education often provides narrow ways for girls and diverse young people to engage with science. Controversially, Osborne et al. (2003) have suggested that when it comes to affective factors related to science, such as interest and attitudes, 'school science education might do more harm than good' (p. 1060). In response to the critique of formal science education failing to engage diverse young people with science, many scholars have turned to the informal science learning sector as possibly being able to provide better science engagement opportunities. It appears to have been widely agreed that informal science learning environments (ISLEs) are better suited to providing more inclusive science engagement opportunities than schools, albeit there seems to be limited evidence to support this.

Settings where people encounter science outside of school are diverse. ISLEs include various spaces and activities outside the classroom. Bell, Lewenstein, Shouse, & Feder (2009) have distinguished between three main types of ISLEs: (i) designed learning environments, such as science museums, science centres, botanical and zoological gardens, aquariums (referred to by Bevan et al., 2010 as 'science-rich cultural institutions'); (ii) organised programmes, such as after-school and community programmes; and (iii) learning that happens outside structured settings, such as at home. The former are of a particular interest regarding this study, but I also consider studies of young people's participation in after-school and community-based programmes, because the rich findings from these can usefully inform work on student engagement with science in other ISLEs.

Many have argued that ISLEs hold the potential to engage young people better with science than schools. This has been seen as particularly beneficial for students who are marginalised when it comes to school science (Bell et al., 2009; Falk & Needham, 2011; Stocklmayer, Rennie, & Gilbert, 2010). By predominantly being located between school and home, ISLEs have been thought of as enabling spaces where the culture of school science and that of everyday life can work together in a way to facilitate better engagement with science. This has been perceived as happening through providing so-called 'third spaces', where the two different cultures can be negotiated (Moje et al., 2004; Stocklmayer et al., 2010). ISLEs have also been argued as being able to support the development of students' science identities better, such as by providing wider ways of doing science and 'being' in science (Calabrese Barton et al., 2012; Carlone, Huffling, et al., 2015; Gonsalves, Rahm, & Carvalho, 2013; Nasir & Hand, 2008). In contrast to mandatory and structured experiences at school, those outside school have been regarded as voluntary, self-motivated and guided by the learner's needs and interests, hence allegedly enabling more and better engagement opportunities (Crane, Nicholson, Chen, & Bitgood, 1994; Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Falk et al., 2012).

Further, Stocklmayer et al. (2010) have somewhat ambitiously proposed that informal science education does not have the limitations of time, structure, inertia, bureaucracy and priorities that constrict formal science education. Consequently, the informal sector has been seen as 'relatively immune to bureaucratic control and hence to ossification' (Stocklmayer et al., 2010, p. 26). In reality, however, informal science learning institutions face other issues and challenges, such as heavy dependency on public funding and rigid institutional structures, even if they might be exempt from following a prescribed curriculum (Department for Culture Media and Sport, 2011; Fenichel & Schweingruber, 2010).

The research literature has offered positive examples of how informal science learning practices have been able to disrupt young people's ideas of what science entails and what it means to be a 'scientific' (Atwater, Colson, & Simpson, 1999; Basu & Calabrese Barton, 2007; Calabrese Barton & Tan, 2010; Gonsalves et al., 2013; Rahm, 2010; Rahm & Ash, 2008; Rahm, Martel-Reny, & Moore, 2005; J. Thompson, 2014). Calabrese Barton & Tan (2010), who worked with young people participating in a voluntary year-round programme on green energy technologies at a local community club, have argued that participation in the programme allowed young people ‘the space and manoeuvrability to be both scientific and youthful’ at the same time (p. 226). It therefore enabled them to take up science identities that were easier to negotiate with their social ones. Participation also gave some youth the opportunities for engagement with science that they struggled to obtain at school. Along similar lines, Rahm et al. (2005) has argued that carefully tailored informal science learning programmes can provide important opportunities for engagement with science for disadvantaged students that they missed at school. Most of these studies have been conducted within community centres and afterschool science clubs outside the UK and over longer periods of time (months or even years). This means that their translation to the experiences of science museum visits might be limited. Further, despite many stories of ‘success’ showcasing improved engagement with science as a result of participation in these programmes, researchers have also warned that even with carefully planned efforts to create the conditions for increasing young people’s engagement with science through long-term participation, some have continued to see science as not for them (Gonsalves et al., 2013; J. Thompson, 2014).

The impacts of science museum visits have been particularly difficult to assess. This is due to the short duration and often one-off nature of visits as well as the various agendas and motivations that people have for visiting them (Anderson, Storksdieck, & Spock, 2007; DeWitt & Storksdieck, 2008; Dierking, 2007; Mortensen, 2011; Rennie & Johnston, 2004, 2007). What visitors get out of the visit depends on a range of personal, social and physical factors, including prior experience and knowledge as well as the social context in which they visit museum, e.g., whether they come with their science class or their family (Anderson et al., 2007; Briseño-Garzón, 2013; Ellenbogen, 2002, 2003; Falk & Dierking, 2000). The outcomes of the science museum visits may therefore include a combination of affective, cognitive, behavioural and social aspects (Falk & Dierking, 2000; Rennie & Johnston, 2004). Some have argued that the sort of learning and engagement that science museums enable might only be notable in the long-term, which presents additional challenges for researchers (Bamberger & Tal, 2008; Paris, 1997). There is also limited data on the impact of school visits to science museums. It has been pointed out that such visits may often be missed opportunities for learning and engagement with science, as they are organised around replicating school-like activities and teachers managing behaviours (J. Griffin, 2004; J. Griffin & Symington, 1997; Tunnicliffe, Lucas, & Osborne, 1997). As a result of having relatively little empirical evidence about the impact of science museum visits, Dierking (2007) has warned that the benefits of these institutions might be taken for granted. I concur with the argument proposed by Rahm & Ash (2008) that 'we need to better understand how such [informal] contexts enable disenfranchised learners to adopt an identity as insiders to the world of science' (p. 50).

In the UK, science museums are an important part of the science learning ecology. Nationally, science museums represent one of the most visited ISLEs. A representative survey of 1,749 UK adults aged 16+ carried out by Ipsos MORI (2014) found that in 2013, nearly a quarter of the British population visited a science museum at least once. Visitors come to science museums in different social groups. The data have shown that the majority of visitors who visit these institutions come as a family (Department for Culture Media and Sport, 2011). Further, science museums are also a popular destination for many nearby primary and secondary schools. The Science Museum London, for instance, has reported that 400,000 of their annual 2.9 million visitors come as a part of school groups, which represents a quarter of all home visitors (The Science Museum, 2012).

Despite the apparent accessibility of science museums, such as entry being free of charge, the data have shown that they tend to have a socially narrow visitor profile. Visitors are predominantly middle class, white and living in urban areas (Atkinson, Siddall, & Mason, 2014; Dawson, 2014a; Department for Culture Media and Sport, 2011; Ecsite-UK, 2008; Macdonald, 2002; Wellcome Trust, 2008). Concerns about visitor diversity in science museums have been raised across Europe (Massarani & Merzagora, 2014) and the US (Bell et al., 2009; Borun, Garelik, Kelly, & Wenger, 2010; Fenichel & Schweingruber, 2010). Visitor demographics therefore suggest that whatever benefits science museum visits might have, some social groups benefit from them more than others. Moreover, it appears that the majority of visitors are people from social groups who already tend to be more privileged in relation to science.

Barriers to science museum visits, most visibly, include factors like financial costs and geographical location. Further, research has also pointed to issues of inclusivity within science museum, whereby it has been argued that these institutions are not inclusive to diverse audiences (Borun & Chambers, 1996; Dawson, 2014b). In addition, it has been contended that designed ISLEs have often been less accessible and more difficult to engage with for visitors from non-dominant ethnic backgrounds (Ash, 2004; Rahm, 2010), which could be at least partially explained by the institutional focus on Western science (Macdonald, 2002), structural inequalities permeating multiple levels of the institutions, such as the (lack of) provision of language resources, the demographic profile of science museum staff and other taken-for-granted expectations visitors are required to observe (Dawson, 2014b). Studies have also pointed out gender challenges, for example, that parents were more likely to explain science to boys than to girls (Crowley, Callanan, Tenenbaum, & Allen, 2001) and that many exhibits are designed in a way to attract and retain boys' attention more than girls' (Dancu, 2010). Further, these findings suggest that for girls from working class and diverse ethnic backgrounds (like the participants in this study), science museums might not be ideally placed to provide inclusive opportunities for engagement with science.

The approach to making practices within science museums more inclusive has largely followed a so-called assimilationist perspective (Bell et al., 2009; Fenichel & Schweingruber, 2010). This has been seen as attempting to increase inclusion without considering the cultural, linguistic and social aspects of the practice. The focus has largely been on removing the barriers and increasing the exposure to the established ways of working. A number of research studies have suggested that people from non-dominant social groups might therefore continue to face cultural, linguistic and social barriers when visiting ISLEs (Archer, Dawson, Seakins, & Wong, 2016; Ash, 2004; Dawson, 2014b; Rahm & Ash, 2008), even when barriers to participation, such as entry fees, are removed.

Regardless of the challenges within science museums, however, given that they are an important part of ISLE ecology in the UK and are visited by many inner-city schools, it is important to consider what they can offer to diverse young people. Furthermore, science museums have been seen as providing valuable research opportunities for studying how young people and families learn science outside school. It has been widely accepted that the family is an important 'educational institution' that operates within a wider learning infrastructure (Ellenbogen, Luke, & Dierking, 2004, p. S40). Further, family visits to places like science museums have been seen as providing researchers with valuable opportunities to study how families learn, converse about and engage with science (Ash, 2003, 2004; Crowley & Jacobs, 2002; Ellenbogen, 2002; Ellenbogen et al., 2004). Examining the experiences of family visits to the science museums is also valuable for unpacking how families are able to support their children's engagement.

Studies focusing on learning and engagement with science within science museums have to date mostly focused on the people who visit science museums (often, who were regular and keen science museum visitors), therefore gaining an understanding largely about visitors who are relatively keen on science and comfortable with visiting science-related cultural institutions. In doing so, research has largely been inward-facing (Crowley, Callanan, Jipson, et al., 2001; Ellenbogen, 2002). There has been relatively little research about the patterns of non-participation in ISLEs (Dawson, 2014a), despite widespread and growing concerns about the exclusivity of these institutions (Atkinson et al., 2014; Wellcome Trust, 2008). A literature review conducted as part of a Wellcome Trust report, for instance, found that out of over 500 academic articles identified as 'free choice learning' and 'informal science learning', only a small proportion included 'disenfranchised' participants or audiences (Falk et al., 2012). The dearth of research work on equity issues in designed ISLEs, alongside the arguments that these spaces might be able to support disadvantaged youths better by offering them opportunities outside the classroom, suggests that there is a strong need for further research.

What emerges from the literature is that science museums could play a valuable role in engaging young people with science, but research and visitor data suggest that these benefits are likely to be higher for people from some (more privileged) social groups than for others. Little empirical evidence has supported the assumptions about science museums being able to facilitate and foster engagement with science among disenfranchised groups. I suggest that what warrants this study's focus on science museums is the opportunity to study the participating girls within different settings (school, science museum), as well as to study how they engaged with science in the context of the family. As I noted above, family visits to science museums provide a valuable opportunity to gain insight into how families talk about and interact with science. Moreover, there have been relatively few studies taking a multi-sited approach to studying young people's engagement with science, particularly in the UK. The majority of studies to date have focused on examining young people's experiences within a single setting, such as in the classroom, an afterschool community club or during a science museum visit. In some cases the observation data from one setting was complemented with oral accounts of engagement with science in other settings. For instance, Calabrese Barton & Tan (2010) have drawn together the data from observations of youth's after school science activities and their reflections on engaging with science in and outside school. The few notable exceptions of multi-sited studies that have included school and out-of-school settings convincingly demonstrate the value of such work, particularly for understanding the experiences and disadvantage of young people who tend to be marginalised in mainstream science education (Calabrese Barton et al., 2012; Callanan & Jipson, 2001; Rahm, 2010). Having a better understanding of the complexities influencing identification and engagement with science can contribute to 'designing [better] learning environments supportive of girls' identity work' (Calabrese Barton et al., 2012, p. 40), which is pertinent for their sustained engagement with science.

1.6 Summary and research questions

In this chapter, I have presented the rationale for this study. I argued that girls continue to be underrepresented in many science-related areas, particularly in the physical sciences. Despite decades of initiatives aimed at encouraging more girls into science, the participation patterns in many areas have remained relatively stagnant. Attracting more girls and women to science is important from a social equity perspective, as well as in terms of scientific progress, economic prosperity and public scientific literacy. I argued that science education tends to privilege the norms and values of science, dominantly constructed as aligned with middle class Western masculinity. Formal science education has thus been critiqued for not providing socially equitable opportunities for students from diverse backgrounds to engage with science. In response to the challenges associated with school science, many have considered informal science learning opportunities as potentially being better suited to support diverse and disadvantaged young people's engagement with science. Informal science learning environments appear to provide opportunities for young people to engage better with science. However, there is currently little evidence as to whether and how visits to science museums could better facilitate diverse young people's engagement with science.

With this study, I aim to contribute to the body of knowledge about how urban girls' from disadvantaged backgrounds engage with science within multiple and overlapping physical settings and social contexts. I examine the girls' engagement with science within two physical settings (science classrooms and science museums) and two social contexts (science class and family). I use the term urban to denote that the girls came from inner-city metropolitan areas with high levels of economic deprivation and ethnic diversity. I consider the girls to be from disadvantaged backgrounds in terms of their socioeconomic situation and their opportunities to achieve good education and employment (Bendit & Stokes, 2003; Li, Devine, & Heath, 2008). I acknowledge that the term disadvantaged is problematic as it is dependent on people's positioning within a particular dominant social structure, but I consider it useful for describing the situation of the participants of this study.

In response to the literature discussed in this chapter, the study presented here aims to address the following two research questions:

1. How do interactions[4] of gender, social class and ethnicity shape girls' preliminary engagement with science?
2. How do interactions of gender, social class and ethnicity shape girls' engagement with science within lessons, class visits and family visits to science museums?

[4] I use the term interactions rather than intersections in the title and research questions because I do not always examine the girls' engagement with science at the 'meeting point' or 'intersection' of all three social axes together, as the intersectionality theory (Anthias, 2013; Crenshaw, 1989, 1991) would suggest.

Chapter 2: Theoretical resources

2.1 Introduction

In Chapter 1, I argued that inequalities in science participation are influenced by multiple social axes. In order to be able to examine how interactions of gender, social class and ethnicity shape girls' engagement with science in this study, it is necessary to consider theoretical resources that allow such an approach. The two main bodies of theory I draw upon in this study are sociologically informed and are namely, Bourdieu's (1977b, 1984, 1986) theory of social reproduction with his conceptual triad of habitus, capital and field and Butler's (1993, 1999) theory of gender performativity. Further to Bourdieu and Butler's original work, I also consider academic work by scholars who have previously adopted and extended these scholars' theories. Bourdieu's theory is primarily useful for examining the role of social class and interactions with ethnicity. Butler's theory puts at the forefront gender and is useful for examining interactions of gender with social class and ethnicity. Both bodies of theory also provide helpful theoretical lenses for interrogating what happens within different social contexts.

I treat the two bodies of theory as complementary. They have arisen from different philosophical traditions, namely structuralism (Bourdieu) and post-structuralism (Butler). Hence, they do not lend themselves to be combined into a single unifying theoretical framework. This approach is reflected in the structure of this and the subsequent discussion chapters, in that I discuss the data analysis through each theoretical lens separately. In this chapter, I begin by briefly introducing the original concepts, examine how they have been built upon and extended by other scholars, consider their application to other social axes and discuss how the theories have been used previously in education and science education research. Further to the discussion of theory in this chapter, I outline how I operationalise these theoretical lenses in Chapter 3. At the end of each discussion chapter, I then provide a brief reflection on the usefulness of particular theoretical resources for unpacking the patterns of engagement with science. I draw the findings together in Chapter 8, the final chapter, so as to consider the overall contribution afforded by these theoretical resources.

2.2 Bourdieu's theory of social reproduction

At the heart of Bourdieu's theory of social reproduction is the attempt to explain how structured social inequalities are transmitted from one generation to the next. Bourdieu has discussed the social reproduction mostly in relation to social class, which he has considered to be the most important factor in producing and reproducing social inequalities. He has debated the theory of social reproduction through the concepts of habitus, capital and field. He proposed that people's social progress depends on the values, attitudes and behaviours that they are socialised with (habitus) as well as the resources they possess and are able to leverage (capital), which have a socially defined value within a particular field. These concepts relate to, shape and determine one another, which Bourdieu (1984, p. 101) has illustrated with a pseudo-mathematical equation: [(habitus) (capital)]+field = practice, thereby suggesting that practice results from the relationships between habitus and capital, which operate within a particular field. I now outline each of the three key Bourdieusian concepts in turn.

Habitus

Habitus refers to a set of deeply embedded and internalised dispositions acquired through social experiences, which informs and shapes practices. This includes what people consider to be possible, thinkable and desirable for 'people like them'. Bourdieu has described habitus as a 'system' or a 'mental and corporeal schemata' of internalised structures, schemes of perception, appreciation, conception and action (Bourdieu, 1977b, p. 86; Bourdieu & Wacquant, 1992, p. 16). According to Bourdieu, habitus is most significantly shaped by early socialisation, such as growing up within a particular social class. Bourdieu (1984) has argued that different conditions of existence tend to produce different habitus and that habitus is, therefore, common to members of a particular social class. People who have similar experiences are consequently more likely to acquire a similar set of dispositions for evaluating and understanding the world (Bourdieu, 1990b). Following this logic, middle class people tend to acquire middle class habitus and working class people tend to acquire a working class one. While habitus is shaped throughout one's life, early socialisation has been argued to carry a disproportionate weight, producing the so-called 'primary habitus' that is the basis for all subsequent formations of habitus (Bourdieu & Passeron, 1990; Bourdieu & Wacquant, 1992).

Bourdieu has argued that habitus is embodied and it operates in a subconscious way, which makes it durable. Habitus is 'a spontaneity without consciousness or will' (Bourdieu, 1990b, p. 56). That is, the internalisation of structures and histories means that habitus becomes a 'second nature', rather than being a product of obedience to the rules (Bourdieu, 1990b). According to R. Jenkins (1992), the durability of habitus comes from 'the thoughtlessness of habit and habituation' (p. 76), as opposed to consciously learning the rules and principles. That is, habitus does not reflect conscious decisions and attitudes, but rather, taken-for-granted attitudes and perceptions that seem 'normal' for people from a particular social group.

Despite its durability, it is important to note that habitus is not fixed, for it is continuously shaped and reshaped by all social and biographical experiences that people encounter through life (Bourdieu, 1983). It is 'the product of [all] history' that is forever ongoing (Bourdieu, 1977b, p. 82). The 'primary habitus' that is produced during early socialisation might later be shaped through other social experiences. The influence of these experiences on a person's habitus depends on the initial dispositions and the alignment between her or his social class habitus with the field she or he encounters (Bourdieu, 1984). Habitus that consistently encounters experiences that produced it in the first place is likely to be reinforced. On the other hand, habitus that encounters experiences that are permeated by different norms and expectations to those that produced it might result in habitus being challenged and modified as a result of these experiences. For instance, working class students who get to study at prestigious universities may change their habitus in response to the exposure, in the attempt to negotiate their experiences in a setting regulated by different norms to those they have taken for granted previously (Reay, 2004c; Travers, 2015).

The importance of habitus lies in its ability to inform and generate practices. It guides people's values, behaviour and thinking. It can condition and constrict what people consider as 'normal' for 'people like them' and whether they find a particular practice or environment suitable for them, or not. For Bourdieu (1977b), habitus 'causes [some] practices and works to be immediately intelligible and foreseeable and hence, taken for granted' (p. 80), while it causes others to be unthinkable. Habitus is also transportable, meaning that it is capable of generating practices and perceptions in fields other than those where it was initially acquired. Put another way, it equips an individual with a set of tools or dispositions that they may be able to use in multiple fields, although the extent to which one's habitus is at ease in another field depends on the alignment between the two (Bourdieu, 1977b; R. Jenkins, 1992).

Habitus, therefore, plays an important role in shaping young people's aspirations, which develop in accordance with their internalised dispositions (Dumais, 2002). Bourdieu has stated that people are not 'fools' and that they 'know how to "read" the future that fits them, which is made for them and for which they are made' (Bourdieu & Wacquant, 1992, p. 130). At the same time, this suggests that people tend to avoid pursuing trajectories that they consider not to be suitable for people like them. A person comes to internalise the social structure, reads what positions are suitable for her or him and acts accordingly. Working class children, following this argument, see working class (manual, unskilled) jobs as more thinkable and desirable for them. In his ethnographic study on working class boys in an industrial English town *Learning to Labour: How Working Class Kids Get Working Class Jobs*, Willis (1977) has argued that the working class dispositions possessed by these boys played a crucial role in directing what they considered to be an appropriate future path for them. He reported that the majority ended up leaving school early and followed the paths of their parents into low-paid manual occupations. Similar findings have also been reported by more recent empirical work, evidencing that social reproduction of disadvantage and privilege continues to shape the trajectories of many young people in the UK, such as in regards of whether to continue on to higher education, or not (Archer et al., 2012b; Ball, 2003; Reay, Crozier, & Clayton, 2010).

Bourdieu's concept of habitus has been critiqued for being too deterministic and for not allowing enough space for agency in favour of structure (R. Jenkins, 1992; Nash, 1990). For instance, Nash (1990) has promoted this critique of habitus as allowing 'no recognition of self, or choice or action' (p. 434), but rather focusing on the taken for granted practices of socialised individuals. Bourdieu and his proponents have rightfully challenged these accusations. Harker (1984) has defended Bourdieu by arguing that the critics who accused his theory of being 'structurally frozen' and with little or no room for agency have not really understood the basis of it in the first place. Bourdieu himself has insisted that the theory of habitus did not rule out strategic choice and conscious deliberation, arguing that individuals are indeed active agents in their thinking and decision-making. In his words, 'habitus may very well be accompanied by a strategic calculation of costs and benefits, which tends to carry out at a conscious level the operations that habitus carries out in its own way' (Bourdieu & Wacquant, 1992, p. 131). Bourdieu has suggested that the fit between habitus and field is only one modality of action, but that nevertheless, it is likely to be the most prevalent one. Put another way, while Bourdieu has maintained that there was space for agency and individual choice, his theory is predominantly concerned with explaining the patterns of disadvantage and the most likely outcomes of a particular condition. Bourdieu's habitus is thus helpful for examining factors that reproduce social inequality at large, rather than unpacking the reasons behind individual action.

Cultural, social and economic capital

Bourdieu's second concept I use in this study is capital, which refers to resources that an individual possesses and is able to use in order to benefit in social and economic situations (Bourdieu, 1977b). In 'The Forms of Capital', Bourdieu (1986) has identified four key types: economic, cultural, social and symbolic capital. Economic capital comprises or is directly convertible into money or material wealth. It is the most independent form of capital and it can be lost or gained most rapidly. Cultural capital refers to non-financial assets, such as taste, ways of talking and body movement (embodied cultural capital), possession of particular works of art and books (objectified cultural capital) and education (institutionalised cultural capital). Social capital includes social networks of friends, family and acquaintances, outlined also as a 'durable network of more or less institutionalized relationships of acquaintance and recognition' (Bourdieu, 1986, p. 51). These relationships include connections that individuals can use in the process of achieving their goals, such as getting a job. Middle class families tend to more successfully combine dominantly-valued economic, cultural and social capital, in order to produce academic achievement and professional success, while working class ones tend to generally be less able to do so (Dika & Singh, 2002). Finally, symbolic capital is seen as honour or prestige and is often the outcome of other forms of capital. It denotes the form that different types of capital take once they are perceived and recognised as valuable and legitimate (Skeggs, 2004a), which may include a job title or a prestigious degree.

Capital is a convertible and transferable resource, which means that some forms can be traded for another and that it can be used across different fields (Bourdieu, 1977b). Cultural capital can be converted into economic capital and the other way around. For instance, educational qualifications can help a person get a well-paid job, while money can be used to purchase tuition fees, visits to cultural institutions, or enable families to move to catchment areas that have access to better schools (Gibbons & Machin, 2008; Smyth, 2009). Further, as Webb, Schirato, & Danaher (2002) have argued, capital can be 'traded for desired outcomes within their own field or within others' (pp. 109-110). Put another way, capital that is gained in one field can be used in a different field. For example, a child whose family often visits science museums and science centres might be able to use their acquired cultural capital in the more formal setting of school science.

Capital transfers, however, are not straightforward and not all forms of capital are equally convertible (Webb et al., 2002). Inequalities in capital transfer have been discussed in terms ‘use’ and ‘exchange’ value, where the former refers to the value of resources per se and the latter to the value in a dominant symbolic sense (Skeggs, 2004c). The value of different forms of capital is produced through the relations of power and depends on the field, such as to what extent it is recognised as symbolically legitimate. Working class resources might have a use value within their own class, but limited exchange value in the field of school or for benefiting in wider social contexts dominated by middle class norms and values. This is because this class’s capital might not be legitimated within it. Hence, working class people might be seen as lacking dominantly valued capital or having the ‘wrong’ kind (Skeggs, 2004a). The most powerful forms of capital are, therefore, those that have the greatest exchange value within the dominant fields.

Bourdieu has been criticised for taking a deficit approach to discussing capital. His argument that people whose resources are not aligned with and valued by the dominant middle class (and Western) are ‘lacking’ capital (without any discussion of their resources being underrecognised, Yosso, 2005) has been thought to potentially maintain the very class hierarchies Bourdieu has claimed to want to remove (Rancière, 2004). While I consider this perspective on capital to be one of the serious limitations of Bourdieu’s work, his theory has been usefully aided by other scholars, who paid more attention to diversity of people’s resources and who challenged the exchange value system of a dominant field. Yosso (2005) and Carter (2003) have raised concerns about the lower value of the so-called ‘non-dominant cultural capital’ or ‘community cultural wealth’ within the dominant fields. Carter (2003) has aligned dominant cultural capital with Bourdieu’s conceptualisation of powerful, high status attributes and non-dominant cultural capital with schemes of understanding and appreciation of the lower socioeconomic and ethnic minority groups that often go under-recognised. Resources associated with ethnic minority groups, thus, tend to have lower exchange value in dominant cultural spaces, but this does not mean that their value should be dismissed.

Bourdieu's discussions of cultural capital have largely focused on the arts, with little reference to science. In *Distinction*, for instance, Bourdieu (1984) has discussed social class and its manifestations on knowledge and taste relating to 'high culture', such as theatre, classical music and fine art. The rare mention of 'science' positioned it in contrast with the arts in terms of its exchange value, as illustrated by the following quote.

> The reader of popular-science monthly *Science et Vie,* who talks about the genetic code or the incest taboo, exposes himself to ridicule as soon as he ventures outside the circle of his peers, whereas Claude Lévi-Strauss or Jacque Monod can only derive additional prestige from their excursions into the field of music or philosophy. (Bourdieu, 1984, p. 24)

For Bourdieu, science-related knowledge had a lower exchange potential than art-related knowledge. While he has argued that knowing about science had little value outside science (and that such knowledge may even be ridiculed), he has maintained that knowing about literary work and the influential thinkers (Jacque Monod was a biochemist, but he also wrote about philosophy) can be valuable across other fields. In one of his last pieces of work, *Science of Science and Reflexivity,* Bourdieu (2004) has discussed the concept of 'scientific capital', which he has regarded as related to recognition of scientists within the field of science. This included, for instance, a scientific publication being cited by another scientist in a scientific journal, which Bourdieu denoted would constitute a form of symbolic capital. His take on science, particularly in *Distinction*, seems overly dismissive of the cultural relevance of many scientific topics. Below, I introduce the notion of science capital (Archer, Dawson, DeWitt, Seakins, & Wong, 2015) that I use in this thesis and argue that, in contrast to what Bourdieu proposed, science plays a vital role in constituting (cultural) capital.

Field

The third of Bourdieu's concepts that I work with in this study is field. Following Bourdieu's pseudo-mathematical equation of how his main concepts relate to one another (see above), a field presents a set of rules, regularities and relations that puts habitus and capital into existence (Bourdieu, 1984). A field is not a physical setting, but rather, a system of power and social relations. It is 'a structured system of social positions – occupied by either individuals or institutions' (R. Jenkins, 1992, p. 85) and 'a network, or a configuration, of objective relations between positions' (Bourdieu & Wacquant, 1992, p. 97). Reed-Danahay (2004) has usefully outlined Bourdieu's way of thinking about a field as a 'field of forces' and a 'field of struggles',

> … a field of forces, whose necessity is imposed on agents who are engaged in it, and a field of struggles within which agents confront each other, with differentiated means and ends according to their position in the structure of the field of forces, thus contributing to conserving or transforming its structure. (p. 32)

A field determines the value of habitus and capital and the two do not function except in relation to one another. Bourdieu & Wacquant (1992) have suggested that the relationship between field and habitus operates in two ways. A field structures habitus and the latter contributes to structuring the former. A field is thus both a product and a producer of habitus that is specific to that field. A field also determines the value of capital and resources that are valuable and beneficial in one field may not be in another, as I discussed above in terms of use and exchange value of capital. The use of capital in a particular field depends on the know-how of how and when to use particular capital, which is informed by habitus. Put another way, it is necessary to know the 'rules of the game' to know how to use capital to the highest potential in a particular field. It is not enough to possess the resources, for these must be mobilised and put in action. As Lareau & Horvat (1999) have argued, capital is only valuable when it is activated and an individual needs to be knowledgeable about how and when to do this in a particular field.

Bourdieu has focused extensively on the field of education and the ways in which education contributes to the social reproduction of inequalities. Because the field of education is based on middle class values, students with this habitus find the values of school more consistent with their own values than those with working class habitus (Bourdieu & Passeron, 1990; Bourdieu & Wacquant, 1992). Bourdieu has further argued that schools tend to often consider the cultural capital of the dominant social groups as 'the natural and only proper sort of capital' and treat children as if they all have equal access to it (Harker, 1984, p. 118). Consequently, taken-for-granted cultural capital acts as an effective filter in reproducing social inequalities (Bourdieu, 1991). The authority of middle class values can, for example, be observed in the case of the language used at school. Middle class students are used to the language at school, because it tends to be similar to the language they use at home. On the other hand, the language of working class students tends to be less similar, which might present an additional challenge for them to fit with the expected norms and behaviours (Reay, 2001a; Webb et al., 2002). To borrow the analogy from Bourdieu & Wacquant (1992), 'when habitus encounters a social world of which it is the product, it is like "fish in the water"; it does not feel the weight of the water and it takes the world about itself for granted' (p. 127). Children from working class and ethnic minority backgrounds are thus more likely to feel like 'fish out of the water' when encountering middle class fields like (science) education.

I mentioned at the end of Chapter 1 that this study examines the girls' engagement with science across two physical settings and two social contexts, whereby I consider a social context to include the people and social groups. I do not equate a social context with Bourdieu's notion of field (Bourdieu, 1984; Bourdieu & Wacquant, 1992). Rather, I use a field as a conceptual device to unpack the norms and expectations within a particular social context (and a particular physical setting), arguing that a field might change within a particular social context, such as through a shift in what is expected and considered valuable by the participants.

Applying the theory of social reproduction to ethnicity and gender

Bourdieu's theory of social reproduction offers a useful 'toolkit' for examining persistent social inequalities related to social class, but it has limited use for discussing ethnicity and gender (Carter, 2003; Reay, 2004b; Skeggs, 2004c; Yosso, 2005). His work has been criticised for being ethnocentric, with white (French) middle class culture representing the norm against which other forms of expressions of culture were judged (Yosso, 2005). Despite the critique and limited resources within Bourdieu's original work for studying the influence of other social axes, his work has been usefully extended by other scholars to include ethnicity and to a lesser extent, gender.

This theory has been extended to consider ethnicity through ethnicity-specific cultural-social capital labelled 'ethnic capital' (Modood, 2004). In contrast to the above discussion of ethnicity-related resources often having limited value within dominant fields, the notion of ethnic capital focuses on those resources that are able to advance socially members of some ethnic minority groups. Ethnic capital has been argued to include ethnicity-specific attitudes and aspirations that are able to, in a way, 'compensate' for the lack of dominantly-valued cultural and social capital, which can contribute to social mobility (Archer & Francis, 2007; Modood, 2004; Shah, Dwyer, & Modood, 2010; Zhou, 2005). The most visible examples of ethnic minorities benefiting from ethnic capital are Chinese and Indian migrants in the US and UK, both of which have far surpassed the educational achievements and social mobility rates of their white counterparts. A study of British Chinese students has argued that these students seem to benefit from community competitiveness within their ethnic community, which promotes high educational aspirations (Archer & Francis, 2007). Science education research has further suggested that South Asian and Chinese students (and their parents/ communities) also hold more positive attitudes towards science and see science-related careers as more thinkable and desirable (Archer et al., 2012b; DeWitt, Archer, et al., 2011). Through the notion of ethnic capital, Bourdieu's work has usefully been extended to provide an approach for examining the influence of people's ethnic backgrounds on their outcomes in life.

A productive alternative approach for examining people's diverse and multiple resources (including related to ethnic background) has been offered by the 'funds of knowledge' literature. This concept is close to non-dominant cultural capital and community cultural wealth (Carter, 2003; Yosso, 2005) and has become a popular thinking tool among scholars working in the area of inclusive education in relation to considering students' diverse experiences and backgrounds (Moll, Amanti, Neff, & Gonzalez, 1992; Rios-Aguilar, Kiyama, Gravitt, & Moll, 2011). The concept of funds of knowledge refers to the historical, cultural and practical knowledge of an individual or a group, which tends to have limited value in a dominant social sphere (González & Moll, 2002; Moll et al., 1992). This way of thinking acknowledges that some resources and experiences have been assigned lower value for having less 'authority of experience' (hooks, 1994). In this thesis, I do not draw explicitly on the funds of knowledge theory, although I do consider the relevant findings of previous empirical studies. I agree with Rios-Aguilar et al. (2011) that funds of knowledge can be interpreted through a Bourdieusian capital lens and thus, fits with his theoretical framework. Rios-Aguilar and colleagues have argued that within dominant (Western, middle class) fields, a funds of knowledge approach has tended to be used 'for the poor' and a capital approach 'for the rich'. Yet, by extending the Bourdieusian framework to consider various resources and ways in which these resources might be constrained by the schemes of recognition and legitimation, I suggest that the conceptual triad of habitus, capital and field can incorporate the ideas framing the funds of knowledge theory.

There appears to have been less success in applying Bourdieu's work to studying gender. While he has acknowledged the role of gender in some of his work, such as in *Masculine Domination* (Bourdieu, 2001), he has received extensive critique from feminist scholars who have considered his work to be inadequate and androcentric. Skeggs (2004b) for instance, has critiqued Bourdieu's approach to gender for a 'striking […] lack of attention to feminist theory' (p. 19), such as by giving too much power to a perceived biological body rather than considering non-hegemonic constructions of gender (see also Laberge, 1995; McCall, 1992). McLeod (2005) has argued that as a result of this, Bourdieu's perspectives on gender 'reproduce standard binaries of masculine domination and female subordination' (p. 19), as if these structures have been unchanged by contemporary life and feminist theory. Put another way, Bourdieu's work seems to have treated the concept of gender in ways that feminist thinkers have long moved on from. It thus has little credibility and possibilities for application to studies of gender. Despite some attempts to apply Bourdieu's theory to gender by feminist scholars (e.g., McClelland, 1990) and acknowledging his contribution in 'enabling feminist scholars to put the issue of class back on the feminist agenda' (Skeggs, 2004b, p. 20), his theories have largely been considered unsuitable for researching such issues. Studies that have sought to work with Bourdieu's theory while also considering gender have, therefore, often complemented his work with other theoretical frameworks, such as post-structuralist gender theory or identity theory (Archer & Francis, 2007; B. Wong, 2012). This is the approach that I also adopt in this study.

The theory of social reproduction in education and science education literature

Bourdieu has written extensively about education, such as in *Reproduction in Education, Society and Culture*, and has considered it to play a key role in reproducing social privilege and disadvantage (Bourdieu, 1984; Bourdieu & Passeron, 1990). Further to Bourdieu's own work, his theories have been widely adopted by the education research community (Archer & Francis, 2007; Ball, 2003; James, 2015; Reay, 2004a) and have been considered to provide a valuable framework for analysing the domination of subordinate groups (McClelland, 1990). The popularity of Bourdieu's concepts like habitus has led to, as Reay (2004c) has remarked, his theory being 'sprayed throughout academic texts like "intellectual hair spray" (Hey, 2003)' (p. 432). Nevertheless, his theory has been usefully applied in a number of science education studies, particularly in relation to student aspirations, identification with science and the exclusion of some social groups from science participation (Adamuti-Trache & Andres, 2008; Archer et al., 2012b;

Claussen & Osborne, 2013; Dawson, 2014b; Ulriksen, Madsen, & Holmegaard, 2010; B. Wong, 2012). The scope and focus of these studies have been diverse, suggesting the potential for a broad application of Bourdieu's work.

Further to research work explicitly drawing on Bourdieu's concepts, several additional studies have approached the issues in science education in ways that I suggest could be interpreted through a Bourdieusian theoretical lens (although the authors themselves did not do so). For instance, some studies have been focused on the role of the family in shaping children's engagement in science education through parental education and qualifications as well as family attitudes to science (Aschbacher et al., 2010; Gilmartin, Li, & Aschbacher, 2006). These factors, labelled by authors as 'family science orientation', resonate with Bourdieu's notions of habitus and capital along with the importance of family and primary socialisation in shaping children's dispositions. In families with little or no science orientation, children were found to be less likely to engage with or aspire to science and parents found it more difficult to support their children's science interests and aspirations when these did arise. Further, Carlone and Johnson's (2007) theorisation of science identity also resonates with Bourdieu's concepts of habitus, capital and field. The three key features that they have proposed determine one's science identity (competence, performance and recognition) could also be seen through a Bourdieusian lens. Specifically, competence could be seen as a form of capital, performance as the interplay between habitus and capital, and recognition as capital valued and celebrated in the dominant field of science.

Science capital

In addition to applying Bourdieu's original work to issues in science education, a concept of 'science capital' has been developed to study the patterns of inequality in young people's aspirations and participation in science (Archer, Dawson, et al., 2016b; Archer et al., 2015). The notion of science capital differs from Bourdieu's 'scientific capital' that I mentioned above, which has been defined narrowly in relation to practising scientists. The concept of science capital has been defined as a conceptual device that collates various types of cultural and social capital as well as dispositions relating to science, as outlined in the following excerpt.

> … a theoretical model of science capital combines the following: scientific forms of cultural capital (scientific literacy; science dispositions, symbolic forms of knowledge about the transferability of science qualifications), science-related behaviors and practices (e.g., science media consumption; visiting informal science learning environments, such as science museums), science-related forms of social capital (e.g., parental scientific knowledge; talking to others about science). (Archer et al., 2015, p. 929)

Science capital has been described as a 'holdall' where young people deposit their science-related knowledge, experiences and other resources that they acquire through science-related experiences in and outside school (Archer, Dawson, et al., 2016b). In this way, the concept of science capital provides a useful focus on science-specific resources, which have not be discussed within Bourdieu's work.

The notion of science capital has been useful for understanding why some people participate in science post-16 and why others see it as 'not for people like them', even despite high attainment and interest in science. It has been reported that science capital tends to be unequally distributed in society and is clearly patterned by social axes. For instance, a quantitative study with 3,658 11-15 year old students has found that 5 per cent of students could be classified as having high science capital and 27 per cent as low, with the former being predominantly white and South Asian boys from middle class backgrounds (Archer et al., 2015). Data have shown that the more science capital a person has, the more likely they are to consider doing science in the future. This thesis makes the notion of science capital particularly fitting with this study.

The work on science capital has also extended Bourdieu's thinking about capital as playing a role in social reproduction, to considering how it could be possible to *build* science capital. Research has made a case for the need to find ways to increase science capital through making science more familiar, relevant and useful for people's lives as well as how to support people's long-term engagement

(Archer et al., 2012b; Archer, DeWitt, et al., 2013). Some aspects of science capital, such as parents' educational qualifications, are clearly relatively fixed and beyond the realm of most interventions. Others, however, such as students' knowledge about the transferability of science skills, are more amenable to change. In line with Bourdieu, the value of science capital depends on a field, which might celebrate some resources and experiences while dismissing others. Further to measuring how much science capital people have, the notion offers a valuable opportunity for examining what can be done within different social contexts to foster ways to mobilise and value the resources young people already possess, but which may have not been given enough consideration within formal education (Archer, Dawson, et al., 2016b; Archer et al., 2015; King, Nomikou, Archer, & Regan, 2015). I consider Bourdieu's theoretical framework to be useful for understanding girls' engagement with science, in particular, for unpacking the role that is played by their socioeconomic and ethnic backgrounds.

2.3 Butler's theory of gender performativity

The second theoretical framework I use in this study is Butler's theory of gender performativity. As Bourdieu's theory of social reproduction offers very limited tools for suitably examining gender, I consider bringing in this theory as important for complementing the theory of social reproduction. I discuss the role of gender through Judith Butler's (1993, 1999) ideas of gender performativity, alongside the work of other poststructural feminist scholars on young people's educational and science-related experiences (Francis, 2005, 2010a; Renold & Ringrose, 2008; Skeggs, 1997; Skelton, Francis, & Read, 2010; Walkerdine, 1989).

Conceptualising gender as socially constructed

In this study, I adopt the perspective that gender is constructed through social norms and practices rather than biologically determined by the biological sex one is born with. Gender is therefore not a 'result' or a 'consequence' of a person's sex, but rather it is produced through discursive acts. Binary sex organisation[5] should, therefore, not imply binary gender organisation. Female bodies do not 'naturally' become gendered as feminine, nor do male bodies 'naturally' become gendered as masculine (Butler, 1999). This perspective on gender has been widely recognised across academic fields, including in science education (Brickhouse, 2001; Carlone, Johnson, et al., 2015). This approach to theorising gender is anti-essentialist, flexible, fluid and discursively produced (Anthias, 2001; Butler, 1999; Hall, 1990). In this way, gender is something that we 'do', not something that we 'are' or 'have' (Butler, 1999). As Hall (1990) has argued, identity (which, I suggest, also applies to gender) is a 'production', which is never complete, but 'always in process'. Gender is also relational, which means that the notion of femininity can only be constructed in relation to masculinity (Francis & Skelton, 2001).

In resonance with Riviere's (1929) earlier ideas of 'womanliness as masquerade' and the work of West & Zimmerman (1987) on 'doing gender', Butler (1999) has extended the idea that gender is a 'performance'.

> … gender is always a doing, though not a doing by a subject who might be said to preexist the deed […] There is no gender identity behind the expressions of gender; that identity is performatively constituted by the very 'expressions' that are said to be its results. (Butler, 1999, p. 33)

In line with the non-essentialist perspectives on gender, this suggests that there is no essence to gender and that the expressions are all that can be known. In Butler's words,

> … acts, gestures, and desire produce the effect of an internal core or substance, but produce this *on the surface* of the body, through the play of signifying absences

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[5] Sex categories are not completely binary either (Francis & Paechter, 2015). Intersex people can have a combination of physical sex attributes that are aligned with characteristics of male and female sex and the determination of their biological sex reflects socially constructed criteria.

> that suggest, but never reveal, the organizing principle of identity as a cause. (Butler, 1999, p. 173, emphasis in original)

Gender identity is maintained by the repetition of gender performances, which over time become largely subconscious, meaning that people might not always be aware that they are 'doing' gender. Renold (2005) has elaborated that gender is actualised through a series of repetitive performances, which constitute 'the illusion of a "proper", "natural", or "fixed" gender' (p. 4).

Even though gender is socially constructed and performative, people do not have an absolute freedom to perform it without any considerations paid to their sexed body. Gender performances reflect the structures that govern the 'appropriate' gendering in relation to normative versions of femininity and masculinity (Francis, Skelton, & Read, 2010). This means that society influences what are acceptable and appropriate performances and social structures, therefore, shape how one performs gender. As Paechter (2003b) has argued, people do not have the opportunity to choose freely what performance they will act when they get up in the morning. Rather, 'we slip into our roles, so imperceptibly that most of the time we do not even notice' (Paechter, 2003b, p. 69). Paechter has added that people only tend to notice how they perform gender when their performances turn out to be a poor fit with the social expectations, thus resulting in tension and conflict. Butler (1993) has similarly maintained that femininity is not a product of choice, but rather 'the forcible citation of a norm, one whose complex history is indissociable from relations of discipline, regulation, punishment' (p. 232). The construction of gender, thus, is shaped by the norms and expectations in society and by a people's desire to fit in (Francis & Skelton, 2005).

Gender performances are recognised in relation to gender attributions. That is, once a gender attribution has been established and a person has been identified as male or female, their behaviours are understood and judged by those around them with a reference to this label (Francis, 2012; Kessler & McKenna, 1978). People tend to belong to, or are placed by others, into one of the two sex-categories. Consequently, as West & Zimmerman (1987, p. 145) have pointed out, 'doing gender is unavoidable'. There is little space for doing gender performances without these being understood in relation to a sexed body, as they tend to be read differently depending on who is performing. For example, wanting to be in control might be perceived as 'strategic' for a boy, but 'manipulative' for a girl (Francis, 2012, p. 9). This further suggests that despite gender not following from sex, the two clearly do not operate completely independently in a society that has constructed a plethora of social norms and expectations for each sex category.

The alignment between gender performances and societal expectations for each sexed body has been discussed in terms of gender 'intelligibility'. According to Butler (1999), only people who perform their gender consistently and in alignment with the expectations for heterosexual social norms are perceived to be intelligible genders. Intelligible genders maintain a coherent and continuous relationship between sex, gender, sexual practice and desire. Women are thereby expected to perform femininity and participate in heterosexual relationships with the opposite sex/gender. For a gender identity to be intelligible, moreover, it is necessary that 'certain kinds of "identities" cannot "exist"' (Butler, 1999, pp. 23-24).

Research has found that people are aware of societal gender expectation from an early age. It has been suggested that already in primary school, girls experience social pressures to perform particular hetero-sexualised versions of femininity that are considered to fit with normative and socially-sanctioned (gender-intelligible) identities (Renold, 2005). From a young age, girls are 'girled' and boys are 'boyed' (Butler, 1993). Children are socialised into gender roles that are considered 'appropriate' within a society. 'Non-intelligible' genders, in turn, can be seen as those where gender does not follow from sex or desire does not follow from sex or gender. These instances might be considered as disrupted and incoherent, possibly incurring social costs for the individuals, such as prejudice and discrimination. The notion of gender intelligibility has implications for how girls negotiate their participation in traditionally masculine areas, including academic ones such as physical science or mathematics.

While it has been widely accepted and agreed that gender is socially constructed, the role of the material body seems to be a more contentious issue. The notion that boys are expected to perform masculinity and girls are expected to perform femininity brings into play a sense of determinism in gender production (Francis, 2010a). Butler's theory has been critiqued for remaining somewhat essentialist due to being limited to discussion of the multiple 'femininities' produced and performed by women, and multiple 'masculinities' produced and performed by men, while not extending these ideas to both women and men performing femininities as well as masculinities (Francis, 2010b; MacInnes, 1998). In order to provide a concept of gender that avoids essentialism and acknowledges the role of the body, Francis (2012) has proposed the idea of gender monoglossia and gender heteroglossia, borrowing the terms from the field of linguistics (Bakhtin, 1981). With this approach, Francis has attempted to challenge the monoglossic model of gender, 'the dominant, binarised model of gender, wherein femininity and masculinity are linked directly to the dualist construction of sexed bodies as male and female' (Francis, 2012, p. 5). This monoglossic model of gender has positioned male/masculine as a hegemonic subject and female/feminine as a subordinate 'other', with the former being privileged over the latter. In contrast with the monoglossic model of gender, the heteroglossic model proposed by Francis is contended to be able to account for the contradictions and 'impossible subjects' (Butler, 2004) that might not fit into a monoglossic binary model. Francis has emphasised the notion of 'denial' in thinking about gender, that is, a monoglossic gender stability being capable of masking or distracting from gender fluidity. In other words, Francis has suggested that by performing femininity girls might 'mask' masculine performances, to give an illusion of a coherent gender. The heteroglossic approach to examining gender could, therefore, offer 'a sophisticated account that can address existing theoretical binaries, acknowledging the role of the material, and of social structures, while simultaneously identifying and celebrating heteroglossic disturbances integral to gender production' (Francis, 2012, p. 1). In this thesis, I take the position that girls can perform both femininity and masculinity, but acknowledge that tensions might arise when performances of gender are not aligned with the societal expectation for their biological sex.

In this study, I use this term 'girls' to refer to the research participants. I am aware of the limitations of this terminology from a post-structuralist feminist perspective. I agree with Francis's (2010b) argument that following the approach that gender is socially constructed, it would be more accurate to refer to these subjects as 'those discursively constructed as female' (p. 481). Yet, I concur with her that this would be 'extremely clumsy' and so like most gender researchers, I retain the shortened terminology.

Applying the theory of gender performativity to social class and ethnicity

It has been widely recognised that patterns of dominance and subordination do not apply equally to all women, nor all men (Connell, 2005). Just as 'hegemonic masculinities' tend to be reserved for white, heterosexual and middle class men, so too do subordinate positions of women depend on the interactions of gender with other social axes. Some studies of gender have previously been accused of not representing all women and not accounting for experiences of women from non-dominant ethnic and classed backgrounds. As West & Fenstermaker (1995, p. 10) have argued, 'feminist thought suffers from a white middle-class bias'. Rich (1979) has referred to this phenomenon as 'white solipsism', i.e., the problem of many feminists not seeing the non-white experiences as precious or significant.

The girls that participated in this study were ethnically diverse and predominantly working class (see Chapter 3 for more details about the study participants). It was therefore important to consider the interactions of gender performances with other social axes. It has been argued that the construction of gender is, indeed, influenced by and interacts with social class and ethnicity, in a way that particular performances might be seen as more or less gendered, and bearing different significance for girls and women from different social backgrounds (Francis, 2000a; Hill Collins, 2002; Reay, 1998b; Walkerdine, 1990, 1998b). Butler (1999) has argued that her theory of performativity is not limited to gender, for it can be extended to and incorporate other social axes. She has proposed that 'the regulatory practices that govern gender also govern culturally intelligible notions of identity', and that 'the "coherence" and "continuity" of "the person" are not logical or analytic features of personhood, but, rather, socially instituted and maintained norms of intelligibility' (Butler, 1999, p. 23). The intelligibility of performances is, therefore, not judged only in relation to gender, but it inevitably includes other social axes. Working class performances of femininity may, therefore, be judged differently from middle class ones, and these may further be mediated by what performances are considered appropriate for girls from particular ethnic minority backgrounds.

Scholars have proposed that performances should be considered from an intersectional perspective. I agree with Archer & Francis (2007) that in order to understand the role of interacting social axes, it is important to address gender, ethnicity and social class as integrally related issues that need to be theorised collectively. These positions do not operate along distinct and clearly bounded lines. Consequently, as opposed to examining them as separate systems of oppression, it is important to examine how these systems mutually construct one another (Collins, 1998). Yuval-Davis (2006) has, similarly, highlighted the notion of the 'triple oppression' of working class black women, arguing that the situation and the consequences of multiple disadvantages might be more complex and potentially more stigmatising than the sum of each. She has suggested that 'each social division has a different ontological basis, which is irreducible to other social divisions' (p. 195), further making an argument that it is important to examine multiple interacting social disadvantages.

The theory of gender performativity in education and science education literature

Unlike Bourdieu, Butler herself has written little about education, but other scholars have usefully adopted her work into education and science education research. Particularly of relevance to this study is the work that has explored the tensions between girls' performances of gender and the aspects of education traditionally constructed as masculine (e.g., high academic achievement, science education) and what implications there are for the ‘intelligibility’ of girls’ performances.

Previous research has highlighted the tensions between performances of femininity and girls’ academic success. While tension between popularity and academic achievement is not specific to girls[6], studies have suggested that the association of intellect with masculinity might make the situation particularly difficult for them. Francis (2010b) has proposed that due to the discursive construction of intellect as masculine, academically successful girls may be labeled with socially undesirable terms associated with the lack of femininity and even asexuality, such as ‘boffin’, ‘spinster school marm’ or ‘bluestocking’. Academic success and ‘keen’ participation at school tend to present challenges for girls’ popularity, which are organised around performances of heterofemininity. This can result in the pursuit of negotiation and balancing strategies to achieve ‘intelligible’ gender performances with academic success. The following quote from Skelton et al. (2010) captures the tension between academic success and desirable versions of heterofemininity.

> … being an ‘acceptable girl’ is not in harmony with being a successful academic achiever: the former involves passivity, accommodation, a concern with social relations and projecting feminine ‘desirability’ whilst the latter demands hard-nosed determination, singularity and concern with mental/intellectual (rather than social) pursuits. (p. 187)

Similar approaches to studying the role of gender have been adopted for science education research, from which it has been argued that girls who are science-keen and aspire to science tend to manage their performances through carefully produced balancing acts (Archer et al., 2012a). As I argued in Chapter 1,

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[6] Research has also noted tensions between academic achievement and popularity for boys, who similarly have to negotiate socially desirable performances of masculinity to balance their academic performance (Archer et al., 2014; Carlone, Webb, Archer, & Taylor, 2015; Francis, 2000a; Francis et al., 2010).

the dominant construction of science as masculine plays an important role in shaping engagement with science for girls who are invested in performing femininity. This is relevant for girls' participation and aspirations, as their tendency to choose art-related and nurturing subjects over science suggests a desire to fit with the presumptive gender-appropriate subjects, while other more traditionally masculine subjects like science might not allow them to do so (Francis & Skelton, 2005).

The vast education literature that has drawn on the ideas of gender performativity offers useful tools for examining the role of gender in shaping girls' engagement with science. Many studies have discussed gender performances and their interactions with social class (and to a lesser extent, ethnicity). In this work, I draw on gender performances discussed in the education literature, and the analytic perspective developed in a project paper (Dawson, Archer, Seakins, DeWitt, & Godec, 2016). I extend it further by including gender performances within multiple social contexts and physical settings (see Chapter 3 for how I carried out the data analysis through a gender lens). The performances include 'sexualised' and 'restrained' versions of heterofemininity (which I label 'hyper-heterofemininity' and 'restrained heterofemininity'), as well as masculine (heteroglossic) performances of so-called 'muscular intellect'. I now briefly outline each of the performances in turn and discuss their relationships with education.

I first consider the performances of restrained femininity. These have been characterised by quietness, passivity and obedience, being largely associated with the behaviour typical of middle class girls in the education literature (Archer, Halsall, & Hollingworth, 2007a; Fordham, 1993; Francis et al., 2010; Skeggs, 2005b; Walkerdine, 1989; Walkerdine, Lucey, & Melody, 2002). Performances of restrained heterofemininity have been discussed through various labels, with some variance in their conceptualisations. Reay (2001b) has called the girls in her study consistently enacting these performances 'nice girls' and Walkerdine (1990) has referred to the girls in her study as 'innocent school girls'. These performances reproduce traditional notions of femininity as quiet and passive (Fordham, 1993; Francis et al., 2010; Walkerdine, 1989; Walkerdine et al., 2002). It has been argued that performances of restrained heterofemininity have a complex relationship with education. While on the one hand, obedience and compliance is expected of girls by their teachers, these performances are simultaneously regarded as 'other' or 'pathologised' for the same reasons (Archer & Francis, 2007). Girls' passivity has been positioned in opposition to boys' activity (e.g., in the classroom, through active participation), which has made it difficult for them to be recognised as academically engaged. As Walkerdine (1989) has argued, good behaviour and rule following might be simultaneously expected and not desired due to its links to passivity and lack of understanding. In her words, 'the very contradictions in the practice set girls up to achieve the very thing which is simultaneously desired and feared – passivity' (p. 275).

The more sexualised versions of heterofemininity have been characterised by investment in physical beauty, 'sexualised aesthetics', heterosexual relationships, flirting and 'trivial' interests such as in celebrity culture (Archer, Hollingworth, & Halsall, 2007; Francis, 2010b; Francis, Archer, Moote, DeWitt, & Yeomans, 2016). These performances have been discussed through various labels, such as 'hyper-heterosexual femininity' (Archer & Francis, 2007; Archer, Halsall, et al., 2007a) and 'heterosexual femininity' (Reay, 2001b). In the education literature, these performances have largely been associated with behaviours typical of working class girls and researchers have framed them as antagonistic to education (Renold & Ringrose, 2008; Skeggs, 2005a). This has been in part associated with the tensions between working class peer popularity and academic achievement along with 'good' student behaviour (Archer, Halsall, & Hollingworth, 2007b; Francis, 2009; C. Griffin, 1985; Renold & Allan, 2006; Skeggs, 1997; Walkerdine, 1990).

Further to the performances of femininity, I also consider the masculine one discussed within the wider education literature, specifically the performances of 'muscular intellect' (Redman & Mac an Ghaill, 1997). These have been characterised by loud, confident and sometimes arrogant displays of knowledge, typical of high achieving middle class boys (Francis et al., 2010; Redman & Mac an Ghaill, 1997). In line with a socially constructed and non-essentialist approach to gender, I maintain that performances of muscular intellect are not limited to boys/male bodies, for they can also be performed by girls.

2.4 Summary

In this chapter, I have introduced the theoretical resources I used in this study, and critically examined their previous applications to education and science education research. I argued that each of the two bodies of theory allows me to interrogate the data from a different perspective, together enabling an analysis of how the interactions of gender, social class and ethnicity shape urban girls' engagement with science. Bourdieu's theory of social reproduction, including the concepts of habitus, capital and field, has extensively been used to examine social inequalities. Particularly useful are also the concepts developed from Bourdieu's original work, such as ethnic capital and science capital, which enable further analysis. Given the limitations of Bourdieu's work for gender research, I explained how Butler's theory of gender performativity is valuable as a complementary theoretical framework. Butler's work has also been usefully applied to education and science education research. I considered performances of gender and class previously debated in the wider education literature (hyper-heterofemininity, restrained heterofemininity and muscular intellect) as being particularly useful for examining girls' engagement with science. Next, I present and discuss the methodology and methods used in this study.

Chapter 3: Methodology and methods

3.1 Introduction

In this chapter, I discuss the methodology and methods I used to address the research questions. I begin by outlining my ontological and epistemological position as well as discussing the rationale for my methodological choices. I then present the study participants and explain the selection criteria and recruitment process. I introduce the Enterprising Science project that this study was a part of and describe the activities that the study participants took part in. Subsequently, I discuss the methods of data collection and data analysis. I conclude the chapter by reflecting on the ethical considerations of relevance to this study.

3.2 Methodological approach

Ontology, epistemology and axiology

I begin by presenting the philosophical underpinnings that guided this study, including my views about the nature of social reality and the ways of knowing about it. Ontology is concerned with the nature of the world, what constitutes reality and whether reality exists independently of our interpretations. Epistemology pertains to the nature of knowledge and ways of knowing, and whether it is possible to ever know 'the ultimate truth' about the social world (Bryman, 2012; Burr, 2003; Ormston, Spencer, Barnard, & Snape, 2014).

In this study, I adopt the position of social constructionism/interpretivism. This means that I consider social reality to be fluid, elusive and socially constructed (ontology), seeing a researcher as only ever being able offer her or his interpretations of the social world and not the presumptive truth (epistemology). Rather than aiming to uncover truths about the social world (as a positivist perspective would arguably aim to), the interpretivist epistemological perspective maintains that social research can only offer different theories and interpretations about the social phenomena it studies (Bryman, 2012; Burr, 2003; Ormston et al., 2014). This epistemological stance appears to be common to most qualitative studies. The position of ontological constructionism, on the other hand, appears to be somewhat more contentious. There are competing perspectives of ontological constructionism (reality is socially constructed and does not exists outside of people's interpretations) and ontological realism (external reality exists outside social representations of it), which have gained different levels of popularity depending on the academic discipline. While social constructionism appears to be widely accepted and used in sociology, this approach has received some criticism within science education. Osborne (1996), for instance, has argued that social constructivism has enjoyed 'a hegemony […] which is undeserved' (p. 53). He has contended that this perspective is in conflict with the realist paradigm of scientific practice that is considered to be central to the discipline.

A competing perspective to social constructionism/interpretivism is critical realism, which I had also considered in the early stages of my study. While extreme versions of realism have largely been challenged and dismissed across the social sciences, the subtler version of critical realism has remained popular in some disciplines, including science education (Osborne, 1996). According to Bhaskar (1998), critical realism is characterised by ontological realism, epistemological relativism and judgemental rationality. It therefore involves taking the position that there might be different interpretations of reality, yet the ultimate reality nevertheless exists, even if it is beyond the human capacity to know about it (Bhaskar, 1975). Critical realism and social constructionism share an epistemological position (interpretivism), but divide on the question of the existence of the ultimate truth. I take the position, however, that it is difficult to imagine that there would be external reality to compare the findings of this study to. I thus agree with Burr (2003), a proponent of social constructionism, that there might not be any absolute standards against which social researchers would be able to judge their claims against, which presents a challenge to the critical realist approach. I thereby maintain that social reality is only ever constructed and does not exist outside our interpretations of it, which is the position I take in this study.

Social constructionism has been accused of not being able to make claims to universality and not providing meaningful contributions to knowledge, because it accepts multiple realities as equally viable (e.g., Osborne, 1996). This accusation, however, can be defended in terms of social justice, which emphasises the importance of responsible and ethical research. While social constructionism may not be able to make comparisons and evaluations against a presumed external reality, this should not imply that it fails to make comparisons altogether. It has been suggested that different constructions can be judged in relation to each other, and I agree with the argument proposed by Burr (2003) that ‘if we understand knowledge, reality and truth as human constructions, we have even more responsibility to think, argue and make up our minds about our views and defend them’ (p. 94). In a similar way, Longino (1990) has rightfully suggested that findings and theories could be ranked according to their level of ‘acceptability’, such as in terms of inclusivity and the needs of the community, which resonates with the focus of this study on social equity.

This study is grounded in the social justice approach to science education, which informs my axiology. Axiology refers to the study of value. In the literature, social justice has been discussed through the concepts of ‘equality’ and ‘equity’, which despite a common goal of producing fairness in society, operate on the basis of different principles. Central to the notion of equality is the idea of distribution (see Fraser & Honneth, 2003), i.e., that everyone should be treated in the same way and given the same resources and access. Equality can therefore produce fairness only if everyone has the same starting point, which in reality is rarely the case. The notion of equity, on the other hand, is based on the idea that different people need different resources and support to succeed in life (Young, 1990). Rather than providing everyone with the same support, the notion of equity respects and considers people’s differences and provides them with the support they require to be successful in life.

In this thesis, I am predominantly interested in the issues of social equity. While all of the participants, for instance, appeared to have equal access to (free of charge) science museums, these opportunities were not necessarily equitable in the sense that they did not recognise the different needs of varied visitors, such as families with English as an additional language and unfamiliarity with cultural spaces. To attend to the issues of equity within this study, I consider theories of inclusive science education, feminist research and research on the reproduction of social inequalities, which is reflected in my choice of theoretical framework. In agreement with social justice scholars (Fraser & Honneth, 2003; Young, 2000), I argue that by examining the issues related to exclusion and disadvantage in educational and cultural systems, there is the opportunity to disrupt the existing structures and challenge the social reproduction.

Rationale for adopting a qualitative approach

To address the research questions, I needed an approach that would allow me to gain an in-depth understanding of how the interacting social axes shape engagement with science among the girls from diverse and disadvantaged backgrounds. I adopted a qualitative approach to address the research questions, because I considered it to be most suitable for helping me 'understand the subjective world of human experience' (Cohen, Manion, & Morrison, 2011, p. 17). Qualitative studies have the advantage of providing an in-depth and holistic account of the social phenomena under the investigation (Merriam, 1998). They tend to focus on a small number of research participants and aim to explore social phenomena in more depth and detail than quantitative studies. For this study, I was interested in understanding social phenomena from the perspective of the participants (Bryman, 2012; Denscombe, 2010), aiming to consider the experiences and perspectives as the participants perceived them (Burns, 2000).

Validity, reliability and generalisability

In this subsection, I provide a brief overview of validity, reliability, and generalisability, covering some of the challenges of using these criteria in qualitative research. I then discuss these criteria in further detail throughout the chapter, to demonstrate that attending to quality criteria permeated this research from the beginning until the completion of the finished thesis. That is, it was not an inspection at the end of process, but rather a quality control throughout all stages of knowledge production (Denzin & Lincoln, 1998).

The concepts of validity, reliability and generalisability were originally developed in the natural sciences and have been associated with the positivist tradition and quantitative research methodology. In quantitative research, validity relates to whether the instrument measures what it claims to measure ('measurement validity'), whether conclusions are warranted ('internal validity'), and whether the results of the study can be generalised ('external validity'). Reliability pertains to whether the findings are repeatable and consistent from one measurement to the next. Generalisability (close to external validity) refers to the extent to which findings apply to the general population and it is often associated with statistical representation of the sample included in the study (Bryman, 2012; Gilbert, 2001; Lewis, Ritchie, Ormston, & Morrel, 2014).

There have been many debates about the suitability of these criteria for qualitative research. Some qualitative researchers have rejected them, seeing them as 'stemming from oppressive positivist concepts that hamper a creative and emancipatory qualitative research' (Kvale & Brinkmann, 2009, p. 244). Rejecting the existing criteria has in some cases led to the creation of new ones. Guba and Lincoln, for instance, have proposed an alternative set of criteria to replace the traditional triad of validity, reliability and generalisability, namely, trustworthiness (consisting of credibility, transferability, dependability and confirmability/ plausibility) and authenticity (Guba & Lincoln, 1994; Lincoln & Guba, 1985). The concept of trustworthiness, in particular, largely parallels the traditional set of criteria; credibility parallels internal validity, transferability parallels external validity, dependability parallels reliability, and confirmability/plausibility parallels objectivity (Bryman, 2012). The attempts to rename and disclaim the traditional terms have been seen as potentially contributing to a dangerous view that qualitative studies are 'unreliable' and 'invalid'. Consequently, many qualitative researchers have advocated against these trends (Hammersley, 1992).

I argue that assuring validity and reliability of qualitative research is important, particularly if it is to impact upon policy and practice (Lewis et al., 2014). Instead of rejecting traditional criteria, scholars have suggested a useful re-appropriation of these, in order to suit the nature of qualitative research better (Bryman, 2012; Cohen et al., 2011; Fontana & Frey, 2000; Hammersley, 1992; Hammersley & Atkinson, 2007; Lewis et al., 2014; Robson, 2011). As Robson (2011) has argued, the problem might be in the 'overly rigid application' of traditional criteria (p. 155), but these criteria should nevertheless be accepted as relevant. The difficulties of applying the criteria of validity, reliability and generalisability to qualitative research are not merely technical, for they also arise from the philosophical underpinnings behind different research methodologies. For instance, constructionists have argued that there is no single reality to be captured in the first place, so replication of findings (to assure reliability) would therefore be an artificial goal and there would be little value in attempting to do so (Lewis et al., 2014). Further, claiming a contribution to generalised knowledge may also be in tension with the ontological and epistemological perspective adopted by most qualitative research. Kvale & Brinkmann (2009), for instance, have argued that a tendency towards generalisation suggests an assumption that knowledge is universal and valid for all places and all times, while the social constructionist approach conceives social knowledge as socially and historically contextualised.

With these challenges in mind, modified ways of dealing with validity, reliability and generalisability of qualitative research have been proposed, which I also adopt in this study. To assure validity, Lewis et al. (2014) have proposed that the qualitative researcher should consider 'the exactitude of research findings, the extent to which they are supported by explanatory evidence and their capacity for drawing wider inference' (p. 356). This can be ensured through data and theory triangulation as well as through providing sufficient evidence to demonstrate how data lead to the findings. To assure reliability, it has been proposed that qualitative researchers should consider the consistency of the research findings (Kvale & Brinkmann, 2009). This could be assured by the degree to which instances are assigned to the same code or category by different researchers or by the same researcher on different occasions (Hammersley, 1992). Validity and reliability are central to any discussion of generalisation and they have to be assured in order to make findings generalisable (Lewis et al., 2014).

Generalisability remains the most contentious criterion in qualitative research and the quest for universal knowledge has largely been replaced by the emphasis on the depth, heterogeneity and contextuality (Kvale & Brinkmann, 2009; LeCompte & Goetz, 1982). However, this does not mean that there is no scope for generalisability in qualitative research (Kvale & Brinkmann, 2009; Stake, 2005). For instance, findings from qualitative studies can be generalised in a way of transferability to other contexts. This type of generalisation differs from quantitative research such that in qualitative research, extrapolations to other contexts are 'logical, thoughtful and problem-oriented rather than statistical or probabilistic' (Patton, 2002, p. 584). This process of generalisation in qualitative studies involves a reasoned judgement about the extent to which the findings of one study can be used as a guide for what might occur in another situation (Kvale & Brinkmann, 2009). Such theoretical and/or analytical generalisation draws on theoretical propositions and statements from the findings for a more general application and can be either researcher-based or reader-based, depending on who is making the generalisation (Kvale & Brinkmann, 2009).

The role of the researcher and reflexivity

In line with the social constructionist approach I adopt in this study, I see knowledge as co-constructed through my interactions with the research participants and through the research process (Burr, 2003). Complete objectivity is therefore not possible, because the concepts I use to make sense of the world are also a part of that social world. As a researcher, I was partial and my identity and social background undoubtedly influenced the research processes as well as the knowledge produced (Denscombe, 2010; Harding, 1991). Many have written about the need for researchers to examine critically their position and the possible bias that this might infer. This has been discussed through the notion of reflexivity

(Archer, 2002; Harding, 1991; Merriam et al., 2001; Reay, 1996a). Ormston et al. (2014), for instance, have urged qualitative researchers to 'strive to avoid obvious, conscious or systematic bias' (p. 22). Yet, research is always undertaken by a 'biased human', being shaped by their gender, sexuality, ethnicity and class as well as their theoretical approach to research (Nast, 1994).

To begin, I outline my own social background. I would describe myself as a white non-British (Slovenian) woman. My parents were university-educated (both civil engineers), which would suggest I could be labelled as middle class. However, social class takes a different form in a post-socialist country than it does in the UK. Further, I suggest that my social class was complicated by my migrating to the UK a decade ago. I speculate that these characteristics may have shaped how I related to the research participants (and how they related to me), how I collected and analysed the data, and how I interpreted the findings. Reflexivity, as Reay (1996a) has reminded us, is not merely about stating who we are, but rather, trying to explore honestly whether any aspects of our identity (such as similarities and differences with the research participants) might lead to bias. In her words, 'reflexive practice should constitute a process of uncovering/recognizing the difference your differences made' (Reay, 1996a, p. 443). Being reflexive involves critically paying attention to the taken-for-granted ways of understanding the world. It involves self-questioning and self-understanding (Burr, 2003; Kawulich, 2005; Patton, 2002). Barnard (1990) has added that reflexivity cannot be achieved by employing simple measures like using the first person. Although, I suggest that first person usefully reminds a reader that the knowledge presented was constructed (rather than hiding behind the pretence of objectivity). I agree, however, that it is important to subject the position of the researcher 'to the same critical analysis as that of the constructed' (Barnard, 1990, p. 75).

My background was different to that of my participants in many ways. I was a relative 'outsider' (Merriam et al., 2001), most notably in terms of ethnic background, social class, and age (at least in relation to the girls). However, at the same time, I shared a recent experience of migration to the UK with many of the participants. My own migrant background was often a helpful point of connection, particularly when interviewing parents. We would, for instance, share our thoughts and experiences about getting settled in the UK as well as our views about education from an 'outsider' perspective. Further, due to speaking English with a non-British accent, I suspect the participants may have not been able to determine my social class background easily. It is difficult to say to what extent these differences and similarities between myself and the research participants contributed to the research process, beyond offering points of connection. As scholars have previously discussed, differences and similarities between researchers and the research participants operate in complicated ways. For instance, it has been suggested that women might be better suited to interviewing other women (J. Finch, 1993) and that coming from a different ethnic groups to research participants might risk misrepresenting their perspectives (Blair, 1995). On the contrary, Cotterill (1992) has suggested that some participants might be more at ease when there is distance between themselves and the researchers; when they feel like they are talking to a 'friendly stranger'. This might allow the participants to have more control over the relationship and feel more at ease revealing sensitive information.

Archer (2002) has previously discussed her experience of conducting a study with British Muslim students, where the interviews were carried out by either a white female or an Asian female researcher, in order to tease out the different implications this had for the participants' responses. Her findings have suggested that the students altered their responses depending on who the interviewer was (or spoke about how they would do so hypothetically, if interviewed by someone of a different gender or with a different ethnic background). However, these interactions were structured in unpredicted and complex ways, with neither combination being clearly a 'better' option. Moreover, given the complexity of social identities in a study like the one reported in this thesis (i.e., the girls from various ethnic backgrounds), it would be impossible to think that researchers and participants could be matched in a way that does not exclude any aspects of their identity/positions (Archer, 2002; Song & Parker, 1995). Further to the discussion on reflexivity in this subsection, I discuss my position throughout this chapter. I hope that these reflections help to shed light onto my role in the research process.

3.3 Research design

Research participants: Girls, their parents and their science teachers

The study included 15 girls (11-13 years old), ten students' parents and four science teachers. Table 3-1 presents the demographic data about the participating girls, including school, year, ethnicity, social class as well as parental education and employment (parental data in bold indicates those who participated in the study). Ethnicity was determined from the interview data with the girls and their parents, reflecting their own descriptions. Social class was determined indirectly from parental education level and employment status (research participants' own self-identification as members of a particular social class have previously rasied concerns, see Savage, Bagnall, & Longhurst, 2001). I recognise the problematic nature of social class labelling, which I suggest was particularly precarious given the recent migration history of many of the participants (Erel, 2010). However, I decided to include social class labelling to indicate the girls' socioeconomic status at the time of the study. Parental education level and employment status have been commonly used by education researchers to denote social class (Gorard & See, 2009; NRS, n. d.). Alternative factors include eligibility for free school meals (e.g., The Royal Society, 2008) and parental income level, but these data could not be obtained for all of the girls in the study cohort.

School	Girls (pseudo nyms)	Ethnicity	Class	Occu-pation – mum	Education – mum	Occu-pation – dad	Education – dad
Northfields School, London	Alimah	Middle Eastern	Working	Un-employed	Secondary school	**Casual jobs**	**Secondary school**
	Aliyah	Black Caribbean	Working	Casual jobs	Secondary school	-	-
	Caitlin	White British	Working	**Nursery worker/ cleaner**	**Secondary school**	Care taker	Secondary school
	Jasmine	Black Caribbean	Working	Shop assistant	Secondary school	**Web designer**	**Secondary school**
	Samira	Middle Eastern	Working	**Un-employed**	**Secondary school**	-	-
	Sharifa	South Asian	Working	Un-employed	University	Shop assistant	Secondary school
Longdale High, Manchester	Amna	South Asian	Middle	Primary school teacher	University	Waiter	Secondary school
	Asqa	South Asian	Working	Un-employed	Secondary school	**Casual jobs**	**Secondary school**
	Cordelia	White British	Working	**Carer**	**Secondary school**	-	-
	Dorota	White Eastern European	Working	**Un-employed**	**University**	Un-employed	Secondary school
	Hayley	Mixed	Working	Primary school teaching assistant	Secondary school	-	-
	Larisa	White Eastern European	Working	**Cleaner/ business owner**	**Secondary school**	N/A	N/A
	Layla	South Asian	Working	N/A	N/A	N/A	N/A
	Niya	South Asian	Working	Carer	Secondary school	**Nursing assistant**	**Vocational**
	Rifat	South Asian	Working	Technician	N/A	Un-employed	Secondary school

Table 3-1: Overview of the girls (with parental data)

Selection criteria and recruitment

The schools were recruited for the wider Enterprising Science (see below) project on the basis of the following *exclusion* criteria: an independent school, low eligibility for FSMs, no availability of performance data, schools with 90 students or less at the end of Key Stage 4 and schools already working with the collaborating science museums. Data on English as an additional language were also considered. According to the Office for Standards in Education, Children's services and Skills (Ofsted) reports, the two schools I worked with both had a higher than national average proportion of students eligible for FSMs, students from minority ethnic groups and students who spoke English as an additional language.

I selected the two schools for this study from the wider project cohort of five schools on the basis of geographical location and the gender factor, with the selection being further shaped by the project constraints. Longdale High was the only single sex school in the project (which I considered would help me recruit more girls into this study), and Northfields School was the only London school included in the particular project activities during 2014-2015, as well as the only school where these activities were delivered already in the autumn term.

I recruited one middle set year 8 class (Longdale High) and one mixed set year 7 class (Northfields School). The year group we would work with at each of the schools had been decided as part of the Enterprising Science project research design. I selected the particular class in discussion with each of the schools individually; any middle set or mixed set class could have been included. At Northfields School, the head of science ('Mr Cohen') suggested I could work with his class, as he was keen on being involved in the project. At Longdale High, the head of science at the time suggested I work with one of the younger science teachers, who appeared to be particularly enthusiastic about participating in additional activities and projects (this was 'Ms Richards', who was later in the academic year joined by 'Mr Bramley').

All students in the two classes (n=54) and their families were initially invited to participate in the study, through information sheets and my brief presentation of the project during their science lessons. I obtained consent from 23 girls in total (17 from Longdale High and 6 girls from Northfields School), from which I eventually selected 15 girls to include in this study. To make the selection, I first of all considered the amount of data I was able to collect for each of them. Initially, I hoped to include students for whom I had a full dataset, but given that this was not achievable (e.g., several girls consented to participate later in the academic year and only eight girls visited science museums with their families), I extended my criteria to the girls whom I was able to collect most data for. I included all those whose parents also agreed to participate (n=10), whether or not they came to the family weekend at the science museum. In addition to this, I also included five girls for whom I had consent from the beginning of the study and the most available data.

All the parents from the two science classes were invited to participate through letters and information sheets sent home by the school, explaining about the study and including a consent form. If they agreed to participate, they were asked to return the form with their contact details. At Northfields School, four girls' parents gave consent to participate at the beginning of the study. At Longdale High, none of the parents initially returned a consent form. Two parents I interviewed in London admitted that they were nervous about agreeing to participate in the study, as they did not think they could contribute much to a research involving 'science'. As this was before I began recruiting parents in Manchester, I recognised that the information sheet that we had been using for the study may have been off-putting for some parents and so, I created a leaflet to accompany it, which I hoped would be able to explain what the study was about in a less intimidating way (see Appendix 1). The second stage of recruitment took place during the 'family weekend' at the science museum. Families who came to the science museum were asked whether they would be happy to participate in the study and all six families from the Longdale High who came to the science museum agreed to take part.

In addition to students and parents, I also recruited four science teachers, because I considered it valuable to obtain their perspectives on the girls' engagement with science (see Table 3-2). Mr Bramley, Mr Cohen and Ms Richards taught the science classes I worked with, whilst Mr Bell was Northfield School's class form tutor. Because he came along on the class visit to the science museum and knew the girls well, I decided to include him in the study too.

Science teachers (pseudonyms)	School	Age	Years as a science teacher
Mr Bell	Northfields School, London	25-29	3
Mr Bramley	Longdale High, Manchester	40-44	10+
Mr Cohen	Northfields School, London	30-34	9
Ms Richards	Longdale High, Manchester	25-29	2

Table 3-2: Overview of the participating science teachers

Enterprising Science project activities

As aforementioned, this study was part of a larger Enterprising Science project, a five-year collaboration between King's College London, the Science Museum Group and BP. The project aimed to help more students find science engaging and useful for improving their opportunities and outcomes in life, through building science capital (see Chapter 2). During the academic year 2014-2015, the research participants from five schools were involved in the activities delivered in collaboration with four science museums. Two of these five schools were included in my study. The aim of these activities was to provide students and their families with engaging science museum opportunities. In terms of the study presented here, I considered these activities as providing the opportunities to investigate the girls' engagement with science within different contexts. I hence predominantly focus on the girls' engagement with science, rather than analyse in depth the features of the activities themselves.

There were three main components of the activities: pre-visit science lessons, class visits to the science museums and family visits to the science museums. All of the students from the two science classes were involved in the project activities, whether or not they consented to participating in the study. In agreement with the school, these activities were part of their science lessons. Data, however, were only collected for students for whom consent had been obtained (theirs and their parents').

The science teachers delivered two science lessons before the visit. The aim of these lessons was to help students become familiar with museum content and prepare them for the upcoming science museum visit activities. During the classroom activities, students in groups of two or three were allocated different museum objects that related to their curriculum (the topic of 'forces') and were provided with resources regarding how to engage with the objects. They were given 'object engagement cards' with information about the objects and an 'object presentation plan' to help them prepare for the class visit activity. The main activity included filming a short presentation about the museum object with an emphasis on being creative and making the video engaging for friends and family. Students were encouraged to consider different presentation styles, such as interviewing, singing and role-playing, to present the museum objects (see Appendix 2 for project resources).

The class visits to the science museums were facilitated by the museum staff and the science teachers from each science class. The visits included the main activity of filming the presentations that the students had previously prepared in class, as well as other activities typical of school visits to science museums, such as shows, interactive galleries and free time to explore. Only one class from each school visited the science museum on that day and they each spent around four hours at the premises. Out of the 15 girls who I included in my final study cohort, 14 came on the school visit to the science museum. Table 3-3 gives a brief outline of the activities the two classes participated in during their visits.

Schools (pseudonyms)	Duration of visit	Overview of class visit: activities and areas visited
Northfields School	4h	Filming presentations, interactive gallery, show on forces, free time for exploration
Longdale High	4h	Object hunt, filming presentation, show on cotton-making, free time for exploration

Table 3-3: Overview of the class visits

Families were then invited to the 'family weekend' at the science museum through a letter sent home by the school and students were encouraged by their teachers to come. Families were offered a lunch voucher and tickets to the museums' 3D/4D cinemas, as well as the reimbursement of travel costs, including a taxi to the museum, day travel card or parking fees. The family visit took place over one weekend in January 2015 for Northfield School and one weekend March 2015 for Longdale High. Upon arrival, the families were shown the videos that their daughters had created during their class visit and were encouraged to explore the museum with the girls being 'the experts'. Eight families in total came to the family weekend from both schools and they spent between two and four and a half hours in the science museum. See Table 3-4 for an overview of the family visits.

Girls (pseudonyms)	Family group size	Duration of visit	Overview of family visit: activities and areas visited
Asqa	3 (Asqa, mum, dad)	-	Not observed
Cordelia	4 (Cordelia, mum, two older friends)	2.5h	Visited several object galleries, an interactive gallery and a cinema
Dorota	5 (Dorota, mum, dad, two younger siblings)	4h	Visited most object galleries, attended a 'meet a scientist' session, and went to a cinema
Hayley	2 (Hayley, mum)	-	Not observed
Jasmine	3 (Jasmine, mum, dad)	4h	Visited three object galleries, an interactive gallery, a plane simulator and a cinema
Larisa	8 (Larisa, mum, younger sister, three adults, two younger children)	2.5h	Visited interactive gallery, one object gallery and a cinema
Niya	6 (Niya, mum, dad, two older sisters, older brother)	2h	Visited several object galleries and a cinema
Samira	3 (Samira, mum, older sister)	4.5h	Visited three object galleries, an interactive gallery and a cinema

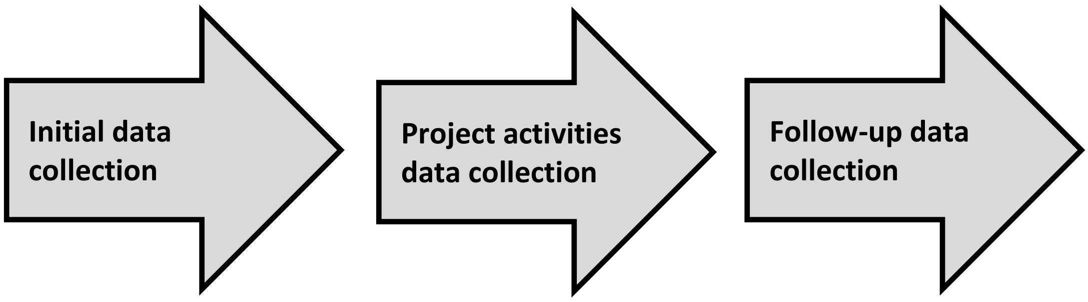
Table 3-4: Overview of the family visits

3.4 Data collection

I used a multi-method qualitative approach involving three methods of data collection: focus groups, interviews and observations. The use of multiple methods of data collection contributed to a more in-depth understanding as well as greater validity and reliability of research findings, as this approach enabled the triangulation of data sources (Bryman, 2012; Denzin & Lincoln, 1998; Patton, 2002; Silverman, 2011; Stake, 2005). Data triangulation assumes that the use of different sources ‘will help both to confirm and to improve the clarity, or precision, of a research finding’ (Lewis et al., 2014, p. 358). Next, I briefly outline the data collection methods employed in this study, why I decided to use each of the methods, and how the data collection turned out in practice.

Overview of the data collection

Figure 3-1 provides an overview of the data collection, including how many participants took part at each stage and how many hours were spent doing observations. For a more detailed breakdown of what data were collected for each of the girls, see Appendix 4.



- Student focus groups (n=10 students)
- Parent interviews (n=4)
- Teacher interviews (n=4)
- Science lesson observations (n=9 lessons)

- Class visits to the science museums (2 days/8 hours)
- Family visits to the science museums (4 days/19.5 hours)

- Student focus groups (n=9 students)
- Student interviews (n=14)
- Parent interviews (n=7)
- Teacher interviews (n=4)
- Science lesson observations (n=9 lessons)

Figure 3-1: Overview of the data collection

Focus groups

Focus groups involve a small group of people who discuss a particular topic and are facilitated by a moderator (Cronin, 2001; Kitzinger, 1994; Kitzinger & Barbour, 1999). The method originated in market research, but has since become commonly used among social researchers. In the literature, the term ‘focus group’ is often used interchangeably with ‘discussion group’ (Bryman, 2012; Cronin, 2001; Lewis & McNaughton Nicholls, 2014). As Kitzinger & Barbour (1999) have proposed, ‘any group discussion may be called a focus group as long as the researcher is actively encouraging of, and attentive to, group interaction’ (pp. 4-5). The key feature of a focus group is interaction, which is what distinguishes it from a group interview (H. Finch, Lewis, & Turley, 2014).

In this study, I conducted focus groups with students at the beginning of the data collection process and again, after the class visits to the science museums. Each of the girls participated in at least one focus group. I considered these to be a useful methods for beginning data collection with, because they tend to provide a more comfortable environment for the participants than other methods, such as interviewing (Bryman, 2012). The aim of the initial focus groups was to get to know the students, their views about science and ‘science people’, to what extent they participated in science outside school and what role their families played in shaping their engagement with school as well as with science. I was especially interested in the interactions during the discussion and how the girls worked out common or contradictory views. The aim of the focus groups I conducted after the class visits to the science museum was to unpack the girls’ experiences of the project activities. A semi-structured focus group schedule (see Appendix 3 for focus group schedules) was followed and they included between three and six students. I deliberately arranged smaller groups in order to allow for a more in-depth discussion (Cronin, 2001) than were it otherwise. I conducted the focus groups in an empty classroom or a teacher’s office. In total, this study includes data from nine focus groups, which they lasted between 11 and 30 minutes.

The students who participated in the focus groups had some level of shared experience and a somewhat similar social background, such as their socioeconomic background, (mostly) growing up in the same area and going to the same school. Scholars have argued that focus groups are likely to work better if there is a level of similarity among the participants (Cronin, 2001). However, even with relative similarity, such as being classmates, the participants had different confidence levels and some were more talkative than others. My role as the moderator therefore included not only asking questions, but also carefully managing the group dynamics, to ensure that the discussions were balanced. This involved encouraging some participants and carefully restraining others from taking over, as well as trying to minimise any simultaneous dialogue that would have interfered with the later transcription (H. Finch et al., 2014). I usually began the focus group by asking the participants to listen to and respect each other and mentioning that I would be very grateful if they could only speak one at the time, so that I could later understand what each of them was saying. I attempted to avoid being perceived by the students as a teacher-like authority figure (although I suspect that this was not entirely doable). For instance, I stressed that I was a researcher from the university, and that our discussions would not be shared with their teachers.

Focus groups were a useful method to start getting to know the girls. They were, however, less suitable for generating detailed individual accounts and eliciting sensitive or personal information. In order to obtain further personal data and give all the participants an opportunity to discuss their thoughts and experiences, I combined focus groups with interviews and observations. As aforementioned, combining data collected through multiple methods was also valuable for data triangulation (Vaughn, Schumm, & Sinagub, 1996).

Interviews

Interviews are a widely used method of data collection in social research (Bryman, 2012; Fielding & Thomas, 2001). They are particularly popular because of the flexibility they offer (Denscombe, 2010). Interviews are suitable for finding out opinions, feelings, emotions and experiences and are an especially desirable method of data collection due to their ability to obtain in-depth data and insights (Denscombe, 2010). A qualitative interview has been defined as a specific form of 'conversation with a purpose' (Berg, 2007, p. 89). Depending on the level of structure and flexibility, interviews can be structured, semi-structured and unstructured. Structured interviews consist of a set of questions designed in advance, with little or no space for flexibility and are most commonly associated with quantitative research. Unstructured interviews, on the other end of the spectrum, have little or no structure, but rather consist of a general idea of what the conversation should be about. Semi-structured interviews (which I used in this study) are situated between the two. There is an interview schedule to guide the conversation, but the interviewer has the freedom to think of new questions as the conversation develops, which allows some degree of flexibility as well as covering a set of pre-designed questions (Bryman, 2012; Denscombe, 2010).

In this study, I carried out interviews with all the participants. I conducted the interviews with the girls at the end of the study. The aim was to get data about their experience during class and family visits (where applicable) as well as getting additional data on their engagement with science that I had not been able to obtain during earlier focus groups. My initial plan was to interview all of the parents twice, before and after the science museum visits, to discuss their own and their daughters' engagement with science and later, their experiences regarding the family visits to the science museums. However, due to difficulties with recruitment, I was not able to conduct all of the initial parent interviews before the family visits. I therefore combined the initial and follow-up parent interview schedules and used this extended version for interviewing the parents after their museum visits. Finally, the aim of the teacher interviews was primarily to get data on how they thought the girls engaged with science, who they recognised as 'science people' and what factors they thought might influence students' engagement with science.

Whenever possible, I conducted interviews face-to-face, although some interviews with parents were conducted over the telephone later in the study. Face-to-face interviewing was a preferable option, because it allowed for a more personal relationship to be developed with the research participants. I used careful probing and prompting throughout the data collection, in order to minimise the bias and increase reliability of the findings (Fielding & Thomas, 2001; Seale, 1999). Probing refers to giving explanations when the questions might be unclear to the research participant and prompting pertains to suggesting possible answers. While both strategies could be useful – and are often unavoidable – it is important to consider that giving a range of different probes and prompts might invoke a range of different responses (Bryman, 2012).

In total, I conducted 14 interviews with students, 11 interviews with parents, and eight interviews with teachers (all four teachers and one of the parents were interviewed twice). I conducted interviews with the students and teachers in an empty classroom or a teacher's office. Student interviews lasted between 11 and 36 minutes, whilst the teacher interviews were of 21 and 36 minutes in duration. I met parents either at their home or at a local café, depending on their preference. I conducted follow-up interviews with parents living in Manchester over the telephone. Parent interviews lasted between 16 and 65 minutes, with telephone interviews being noticeably shorter than those conducted face-to-face.

Before the beginning of each interview, I spent a few minutes chatting to the participants in an informal manner. I considered this to be especially important when meeting the parents, as this was mostly the first encounter we had. Our initial conversations revolved around how their day was going, the local area and getting food and drink. When we met at a café, we would spend some time ordering coffee/tea and when I visited the parents at their home, I would be offered a drink and in one case, even a delicious Middle Eastern feast. This gave us plenty to chat about before starting with the recorded interview. A potential for a high level of rapport, a high degree of reciprocity on the part of the interviewer and maintenance of non-hierarchical relationship has been argued to be one of the key strengths of qualitative interviewing (Bryman, 2012; Oakley, 1981). I emphasised to all the interviewees that even though I was audio recording our conversation, the transcription would be annonymised and no one would be able to recognise who the particular words came from. I also stressed to the girls and their parents that I would not disclose anything they would tell me to the teachers.

While good rapport before and during the interview was important, I was aware that it might also contribute to inconsistencies, such as through participants feeling pressure to give socially desirable responses (Kvale, 1996; Watson, 2006). My interaction with the interviewees was, therefore, a 'delicate balancing act' (Bryman, 2012, p. 218). It has been argued that interview data might be influenced by the so-called 'interviewer effect' or 'interviewer bias'. However, I suggest that participants are likely to give different responses depending on who interviews them and even the same interviewer might differently shape the interviewees' responses, such as by giving different verbal comments and non-verbal cues (Denscombe, 2010). As Fielding & Thomas (2001) have remarked, interviewers are, after all, human beings and their different approaches should, in general, be taken as interviewer 'difference', not necessarily 'bias'. Kvale (1996) has argued that while reliability is important to counteract subjectivity, too much attention on assuring reliability might have negative implications for the creativity and variability of a research project.

Following the epistemological position I outlined above, I considered the data I collected during interviews and focus groups as mutually constructed through collaboration between myself and the participants (Gubrium & Holstein, 2011). As a researcher, I was not a passive 'vessel' through whom the knowledge was transmitted, but rather, an active participant in the construction of knowledge (Kvale & Brinkmann, 2009). As Gubrium & Holstein (2011) have argued, no matter how hard an interviewer might try to restrain their presence, the interviews are 'interactional accomplishments rather than neutral communicative grounds' (p. 150). Kvale & Brinkmann (2009) have usefully illustrated the co-constructed nature of the interview knowledge with the metaphor of an interviewer as a traveller, who sees knowledge as something that does not already exist, but is created through the interview journey, with both interviewee and interviewer actively participating in the process. On the other hand, they have positioned an interviewer as a miner, who understands knowledge as buried metal underground and aims to uncover it in an unpolluted form, which fits more closely with the positivist approach. J. Miller & Glassner (2011) have defended the constructionist interview by arguing that while the 'interview itself is a symbolic interaction, this does not discount the possibility that knowledge of the social world beyond the interaction can be obtained' (p. 133).

Observations

The third method of data collection was observation. Observations allow data collection in participants' 'natural' setting (Flick, 1998). As Jorgensen (1989) has argued,

> Through participants observation, it is possible to describe what goes on, who or what is involved, when and where things happen, how they occur, and why—at least from the standpoint of participants—things happen as they do in a particular situation. (p. 12)

Observations are generally useful for understanding the context and gaining insight into issues and behaviours that people might be less aware of or they might not find significant enough to discuss. They can help the researcher to move beyond what people say they do. Observing 'in action' allows data collection of what happens, as interpreted by the observer (Denscombe, 2010; Patton, 2002). Observations have most commonly been associated with ethnography (Hammersley & Atkinson, 2007), but have also been widely used as part of other approaches, often combined with other methods of data collection, such as interviews and focus groups (Bryman, 2012; Jorgensen, 1989).

I carried out observations in two different physical settings, science classrooms and science museums, observing in total 18 science lessons and two class visits. During the science lessons, I usually sat at the back of the classroom, in an attempt to be as unobtrusive as possible. During my initial observations, I asked the teachers for a class list with student names and sketched out a seating plan, which was useful in helping me keep observation notes for all those with a consent to participate in the study. Further, I carried out observations during the girls' visits to the science museum. I observed two class visits to the science museums and four family visits. During the museum visit observations, I tried to balance not being intrusive to the participants' visit, yet close enough to be able to record their conversations. I adopted the position that Gold (1958) would refer to as an observer-as-participant. I agree with his argument that being a complete observer is nearly impossible, if the researcher is to undertake the observations in person.

While I tried to minimise my interaction with the participants, complete non-interaction was impossible. I recognise that my sheer presence in the classroom and in the science museum might have influenced participants' usual behaviour and interactions. Avoiding interactions was particularly difficult when observing the museum visits, as this involved following a small group of students or a family group for a few hours. I suggest that my presence as an observer may have risked contributing to the so-called 'Hawthorne effect', whereby participants potentially try to appear more active and engaged owing to their being observed.

To capture my observations, I wrote descriptive and reflective field notes[7] (Bogdan & Biklen, 1982). I used observation schedules to guide my observations and note taking (see Appendix 3 for the observation schedules). This allowed a 'focused observation' where I paid attention to the matters of specific interest (Jorgensen, 1989, p. 83), in this case engagement with science, with particular attention to indicators related to gender, social class and ethnicity. While the observation schedules were helpful for increasing my focus, as Hammersley & Atkinson (2007) have argued, field notes are always selective and it is impossible to capture everything. Descriptive notes included detailed observations of the activities, behaviours and conversations that occurred as well as participants' verbatim quotes whenever possible. I kept notes using a tablet (an iPad) and tried to finish them as soon as possible after the sessions. Whenever possible, I finished the field notes the same day, or at least before the new round of observations, so as to avoid the 'erosion of memory' associated with the input of new information (Fielding, 2001; Hammersley & Atkinson, 2007). In order to capture the conversations during the science museum visits, I also asked some of the girls to carry a microphone for audio recording, which I later listened to in order to complement my notes with verbatim transcriptions. After each observation session, I also made reflective notes to help with the later coding of data, which included my comments, remarks and

[7] In this thesis, I use the terms field notes and observation notes interchangeably.

comparisons with previous observations. My field notes amounted to 90,000+ words of descriptive notes, with a further 10,000+ words of reflective notes.

Observations were valuable for gaining the data about the girls' engagement with science in practice, although it was often difficult to say to what extent they were engaging with science (or doing something else that may have looked like engagement). For this reason, it was useful to triangulate the observation data with the data from other sources, in this case follow-up focus groups and interviews (Cohen et al., 2011; Patton, 2002).

Managing the data collection as part of working within a larger project

The project activities I outlined above directed this study, in that I collected data before, during, and after these. Being able to observe and later follow-up on the activities provided me with the valuable opportunity of taking a multi-contextual approach to investigating the girls' engagement with science. My involvement with the larger project also meant that, in some instances, I had to combine my data collection schedules with questions and prompts that were of interest to it but I did not include these in my data analysis, such as specific questions about the project activities. In this way, I collected data jointly for my study and for the Enterprising Science project. The data collection schedules presented in the Appendix 3 are the final combined versions. The selection of data to include in the analysis was not straightforward. Following a semi-structured approach to conduct interviews and focus groups, it meant that there was not necessarily a clear distinction between the data I aimed to collect for this study and those mostly relevant for the larger project. Consequently, I carefully considered all the data that I collected and then coded instances relevant to my research questions (see further details about how I conducted the data analysis below).

Working as part of the team also meant that other researchers were involved in collecting data. As much as possible, I aimed to collect my own. However, due to the nature of the project activities, this was not always the case, and a small part of the data I use in this study were collected by two other researchers who were working on the Enterprising Science project. Specifically, these data included observation notes from the Northfields School class visit to the science museum and observation notes from two Longdale High family visits. In the case of the former, a colleague and I both observed the students for the duration of their visit. At the start of the day, we decided which students each of us would focus on, with the aim being to get as much data as possible about the six focal girls who I included in my study as well as to capture other data relevant to the larger project. As students were often working in smaller groups, it was very valuable to have two sets of observation notes. In the case of the Longdale High family visits, notes were taken by two additional researchers. As I mentioned above, the family visits for each school took place over one weekend. Parents were instructed to arrive anytime between 10 am and 3 pm. Inevitably, there was some overlap among the six families who visited the museum. Cordelia and Dorota's family visits were observed by other researchers. The family visits overlapped (four Longdale High families went to the science museum on the Saturday), which meant that even with additional researchers, it was not possible to keep notes for all the visits. Hayley and Asqa's family visits were not observed.

Pilot study

A pilot study refers to a small version of a full study or a pre-testing of a method or a schedule. Piloting the data collection schedules is important in order to ensure the questions are clear to participants. Piloting the research methods is also helpful for gaining experience and confidence with the schedule as well as assessing the flow (Bryman, 2012). In spring/summer 2014, I conducted a pilot study, which included science lesson observations and two focus groups at Northfields School and Longdale High (all but three participants were different than in the following year's study). The pilot study was useful for testing the focus group schedule in terms of length, appropriateness and fluidity. As a result, the focus group schedule was very slightly modified. I rearranged the questions in order to improve the flow of the discussion, but I made no content adjustments to the schedule. In addition to trialling the data collection schedules, the pilot study also provided a valuable opportunity to start building relationships with teachers and schools. As no substantive changes were made to the focus group schedules following the pilot study, I included the data from the two focus groups I conducted in June 2014 in the data analysis for the study presented here (Layla, Rifat and Hayley took part in these focus groups).

3.5 Data analysis

Recording and transcription

All interviews and focus groups were audio recorded. Permission to do so was sought through written consent and again verbally at the beginning of each data collection session. The recordings enabled the capturing of the sessions in their entirety, which allowed for a more thorough examination of what the participants said (Bryman, 2012). Verbatim note-taking would be very difficult during interviews and could interfere with listening and attentiveness to the conversation (Patton, 2002).

Most of the audio recordings were transcribed verbatim externally by a professional transcriber, who signed the confidentiality agreement. I subsequently listened to all of the recordings myself in order to check for accuracy as well as to familiarise myself with the data. As this study was not concerned with conversation analysis, the transcriptions did not include linguistic annotations (Kvale & Brinkmann, 2009). Transcriptions were mostly sufficient and very little editing was required after the recordings had been transcribed externally. Kvale & Brinkmann (2009) have warned that verbatim transcription used in published work might sometimes present an ethical challenge, as oral language transcribed verbatim might appear to be incoherent and could indicate a lower level of intellectual ability, thus potentially wrongly representing the research participants. I followed the authors' suggestions that this could be avoided by carefully reviewing the quotations used or correcting minor grammatical errors. When I considered a quote to be difficult to understand or was potentially wrongly representing a participant, I made the decision to rephrase/summarise their response in a text rather than insisting on using verbatim quotations. This was the case for a few instances when a participant (e.g., Samira's mum) spoke poor English, using incorrect tenses and needing longer to remember a suitable term. In this case, I considered rephrasing her response to be a more suitable way to capture our discussion.

Initial coding and familiarisation with the data

Analysing qualitative data is a lengthy process, as qualitative research often involves a great amount of audio and written data. To carry out my analysis, I began by importing the data into *NVivo*, a qualitative data analysis software that enables organisation and coding of data. The first step I took was gathering and organising the demographic data in order to create profiles for each of the students. This was inspired by case study research in science education that I found particularly useful (Calabrese Barton et al., 2012; Carlone, Johnson, et al., 2015). This step helped me to familiarise myself with the data and to start organising it. Following the initial sorting, I moved on to mapping out the girls' engagement with science and then analysing this through the two theoretical lenses. Throughout the following subsections, I explain each analytical approach and include examples of codes and data. This is not to provide an exhaustive overview of the coding process, but rather, to illustrate with excerpts from my transcripts and observation notes how I carried out my coding in practice.

Coding and analysing the girls' engagement with science

I approached the analysis of data on the girls' engagement with science by considering their preliminary engagement with science and their engagement with science in practice. The coding process was deductive, drawing on the student engagement theory outlined in Chapter 1, as well as inductive in order not to dismiss any instances that did not fit with these theories. I reviewed my ongoing coding and categorisation with colleagues and supervisors, to increase reliability of my findings and to consider a wider range of possible perspectives (Bryman, 2012).

To explore the girls' preliminary engagement with science, I initially coded the girls' interests in science, attitudes towards science, identification with science, and their aspirations. Through the analysis of data and mapping out the girls' preliminary engagement with science, I decided to put at the forefront identification with science and aspirations (see Chapter 2). This led to me constructing five categories of girls' preliminary engagement with science. This was not to neglect interests and attitudes. Indeed, the girls in the study articulated that liking science was important for continuing studying science or considering working in a science-related occupation (e.g., Hayley remarked: 'obviously you don't want to be a scientist if you're not interested in it'). The girls' interests and attitudes were, however, in many cases, very versatile, specific and rarely applied to science as a whole, which made it difficult to devise a useful categorisation encompassing all the factors. I therefore made an analytical choice to categorise the girls on the basis of their identification with science and their aspirations and discuss the aspects of interest and attitudes within these (see Chapter 4). This decision was further influenced by the emphasis on identification with science and aspirations in previous science education work and the findings that young people's interests and attitudes cannot explain why young people are not aspiring to engage with science (Archer et al., 2015; Archer, Osborne, et al., 2013).

When coding the girls' identification with science, I distinguished between intrinsic and extrinsic reasons why the girls considered themselves to be a 'science person' (B. Wong, 2016). Intrinsic reasons included interest, enthusiasm and sense of belonging in science. Extrinsic reasons were mostly associated with pragmatic factors and/or future science-related aspirations. For aspirations, I used a broad definition of 'scientific' careers as those for which 'scientific knowledge, training, and skills are necessary for the work that they [people] do' (The Royal Society, 2013, p. 3). I combined this with the girls' own perspectives on whether they considered their aspiration to be science-related. For instance, Niya wanted to become an interior designer (which could possibly be seen as a 'scientific' career taking a very broad definition, through its associations with engineering and design), but she insisted that she did not see her aspiration as science but instead art-focused.

Hence, I categorised her as having a non-science-related aspiration. Table 3-5 gives a few data examples of how I coded the girls' identification with science.

Codes (examples)	Data
Identifying – intrinsic	*SG: 'Would you say you are a science person?'* *Dorota: 'Yeah, definitely.'* *SG: 'What do you think makes someone a science person?'* *Dorota: 'Curiosity probably, sort of curiosity, I think thinking about how the world works and I'm always going to my mum just like, I don't know, mum, how does the gravity work* *[…] I love science, I do love it, I find it really interesting.' (Interview, June 2015)*
Identifying – extrinsic	*SG: 'And would you say you're a science person?'* *Asqa: 'Yeah, because I want to choose that in my career […] because my parents, like all these Asian parents, they want you to be either a doctor, a lawyer or an engineer, these are the three options, because they want them to feel proud that they have a son or a daughter like that.' (Interview, June 2015)*
Dis-identifying	*Rifat: 'I'm not a science person, but I enjoy it. Because, I'm OK at science, but I'm not that good.' (Focus group, June 2014)*

Table 3-5: Examples of coding – identification with science

The data on the girls' aspirations are provided in Table 3-6, which also presents the five categories of the girls' preliminary engagement with science: strong, partial-problematic, partial-pragmatic, partial-selective, and dis-identification with science. I discuss each of the five categories in more detail in Chapter 4.

Preliminary engagement with science		Girls (pseudonyms)	Identification with science	Aspiration
Strong		Dorota	Yes – intrinsic	Doctor or astronomer
		Samira	Yes – intrinsic	Research scientist
Partial	Problematic[8]	Hayley	Unsure	Medical research scientist
	Pragmatic	Amna	Yes – extrinsic	Something science related (unspecified)
		Sharifa	Yes – extrinsic	Scientist or science teacher
		Asqa	Yes – extrinsic	Doctor, pharmacist or dentist
	Selected	Cordelia	No	Midwife
		Rifat	No	Games designer
		Aliyah	No	Games designer
		Layla	No	Psychologist or physiotherapist
Dis-identification with science		Caitlin	No	Actress
		Jasmine	No	Singer/actress
		Alimah	No	Singer
		Niya	No	Interior designer (art)
		Larisa	No	Science fiction writer

Table 3-6: Typology of the girls' preliminary engagement with science

For coding the girls' engagement with science in practice, I focused on behaviours and performances. For instance, codes included 'asking questions', 'investing energy' and 'avoiding work'. I began by using a thematic analysis approach (Braun & Clarke, 2006), identifying patterns in my data through an iterative process of moving back and forth from the codes/categories to the data. I then started categorising these codes in relation to levels of engagement. I drew on the literature on student engagement and their organisation of engagement as 'agentic', 'compliant' and 'disengagement' (Bempechat & Shernoff, 2012; Crick & Goldspink, 2014; Nystrand & Gamoran, 1991; Reeve, 2012; Reeve & Tseng, 2011), as well as more specific examples from the science education literature (Barriault & Pearson, 2010; Borun & Chambers, 1996), in the process of iteratively coding observed and articulated behaviours of engagement with science in practice.

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[8] Hayley expressed doubt as to whether she would identify with science and mentioned that she did not think her teachers or her mum saw her as a 'science person' (she also commented on her classroom behaviour often being problematic). Due to these articulated tensions, I categorised Hayley's preliminary engagement as 'problematic'.

I was particularly interested in the instances of substantive or deep ('strong') engagement, which has been characterised as prolonged, purposeful, authentic and action-oriented (Crick, 2012; Reeve, 2012). This form/level of engagement has been argued to involve active, constructive, persistent and focused interactions with the social and physical environment (Furrer & Skinner, 2003); investment of personal resources and positive affect (F. S. Azevedo, 2006); active expression of thoughts, critical engagement with the content and the use of culturally relevant tools (Lawson & Lawson, 2013); action initiation, effort, persistence, intensity, attention, involvement, absorption (behavioural) as well as enthusiasm, interest, enjoyment, satisfaction, pride, vitality and zest (emotional engagement) (Skinner, Furrer, Marchand, & Kindermann, 2008; Skinner et al., 2009).

I constructed four categories of engagement with science (see Table 3-7): strong, partial-problematic (attempting to engage but being denied/shut down), partial-compliant engagement (visibly engaging only to the extent of following instructions or meeting expectations) and disengagement. The terms I used to label the girls' engagement with science are relative to this cohort. This means that the girls I classified as having 'strong' engagement with science may have been in a different category, if a different study cohort was recruited (e.g., there were more students who engaged strongly with science). This categorisation refers to how the girls engaged most of the time within a particular context. For instance, I categorised Alimah's engagement during the class visit to the science museum as 'disengagement', because she was most of the time not participating in any activities, although there was one exception that I discuss separately.

Girls (pseudonyms)	Preliminary engagement with science (*see* Table 3-6)	Engagement with science during science lessons	Engagement with science during class visit	Engagement with science during family visit
Dorota	Strong	Strong	Strong	Strong
Samira	Strong	Strong	Partial – problematic	Strong
Hayley	Partial – problematic	Disengagement	-	N/A
Amna	Partial – pragmatic	Partial – compliant	Partial – compliant	-
Sharifa	Partial – pragmatic	Partial – compliant	Partial – compliant	-
Asqa	Partial – pragmatic	Partial – compliant	Partial – compliant	N/A
Cordelia	Partial – selected	Disengagement	Disengagement	Strong
Rifat	Partial – selected	Partial – compliant	Partial – compliant	-
Aliyah	Partial – selected	Disengagement	Partial – problematic	-
Layla	Partial – selected	Disengagement	Disengagement	-
Caitlin	Dis-identification	Disengagement	Disengagement	-
Jasmine	Dis-identification	Disengagement	Disengagement	Disengagement
Alimah	Dis-identification	Disengagement	Disengagement	-
Niya	Dis-identification	Partial – compliant	Partial – compliant	Partial
Larisa	Dis-identification	Disengagement	Disengagement	Disengagement

Table 3-7: Typology of the girls' engagement with science

Engagement was not always easy to observe, as other researchers have noted (Bempechat & Shernoff, 2012; Nasir & Hand, 2008). At school, for instance, the girls were expected and obliged to participate in specific tasks set out by their teachers and it was sometimes difficult to tell whether and to what extent they were engaged. As Nasir & Hand (2008, p. 173) have put it, 'sitting and listening are not necessarily distinguishable from sitting and daydreaming'. It has also been suggested that challenges in observing engagement can arise from expressions of engagement being culturally and contextually relative and subject to interpretation (Engle & Conant, 2002). For these reasons, I tried to triangulate my observations of engagement with the participants' own accounts, whenever possible, in order to increase the validity of the findings. Table 3-8 presents a few examples of what I coded as engagement with and disengagement from science during science lessons and class visits to the science museums.

Category	**Codes (examples)**	**Data**
Engagement	Volunteering/ participating in science lessons	*The usual few students put their hands up – Samira, four boys. (Observations, NS science lesson, November 2014)*
	Explaining science to others	*Mr Bramley tells them that scientists would use chromatography to solve the crime – many of the girls nod that they remember doing this last year. Dorota explains to Nicole what chromatography is. (Observation, LH science lesson, June 2015)*
Rejected engagement	Attempting to engage but denied	*Aliyah starts talking about the Apollo, but the boys laugh at her pronunciation of the name, so she stops. […] Aliyah starts trying to do her presentation again 'OK this is the Apollo lunar…' and her male classmate shouts 'CUT!' over the top. (Observations, NS class visit, November 2014)*
Disengagement	Avoiding work/ doing other things when meant to participate	*Jasmine is singing and dancing in her chair, playing drums on the table. Caitlin is spending a lot of time sorting out her long blond hair, making different hairstyles. (Observations, NS science lesson, July 2015)*

Table 3-8: Examples of coding – engagement with science during lessons and class visits

It has been argued that engagement tends to be easier to observe when it is voluntary rather than mandatory (Nasir & Hand, 2008). Previous studies in science museums and other ISLEs have attended to engagement by focusing on interactions with exhibits and visitor conversations (Crowley, Callanan, Jipson, et al., 2001; Gutwill & Allen, 2010). Across the six sets of field notes from the family visits, there were few instances of what previous studies have considered to consist of substantial engagement, such as having extended science-related conversations (S. Allen, 2002; Crowley & Jacobs, 2002; Ellenbogen, 2002). For instance, Zimmerman, Reeve, & Bell (2010) studied family engagement in a science centre by looking at 'family sense-making significant events', which they defined as conversations with a clear beginning and ending that involved at least two family members and included science content. None of the conversations I noted during the family visits in this study 'qualified' for this level of engagement. Ash (2003) has examined family engagement in science museums through the notion of 'representative dialogic segments', consisting of the presence of thematic knowledge, the use of enquiry skills and sustained sense-making dialogue. Again, data examples the author has discussed seem to boast a level of engagement with science that I did not observe during any of the family visits in this study. I anticipate that the conversations I observed during the visits would not qualify as substantial engagement in these previous studies. Yet, given that the families participating in this study were relatively unfamiliar with science museums and generally did not engage with science-related activities at home, I argue that it was important to broaden what engagement with science entailed.

Behaviours that I coded as indicating engagement during family visits included explaining to others about science, asking/answering questions, initiating conversations about science, commenting on or explaining exhibits, reading explanatory text aloud/silently, referring to past experiences, sharing information with others, calling someone to have a look and reading signs (Barriault & Pearson, 2010; Borun & Chambers, 1996). As I argued in section 1.4, I considered it to be important to record acts that may have not directly indicated engagement with science, but that included conversations about the museum objects in other ways, such as relating them to life in the country of origin. I contend that these acts indicated a possible sense of connection and meaning making in relation to science, which is often a necessary path towards more substantial or strong engagement (Nasir & Hand, 2008). In order to be inclusive of the various aspects of engagement with science, I therefore considered all activities that involved the broad notion of science (Zimmerman, 2012), including those that were organised around *connecting* to science-related objects or topics.

Category	**Codes (examples)**	**Data**
Engagement	Conversation about museum objects	*Samira's mum keeps pointing at objects and making comments in Arabic to Samira. (Observations, family visit, January 2015)* *Dorota leads her sister over to the dress made from flowers – 'quickly quickly, come here, come on' – 'do you know what that is, it's a coat made*

Category	Codes (examples)	Data
		of flowers, is that cool?' . (Observations, family visit, April 2015)
	Conversation about science	*Cordelia explains that it's about how much friction acts on something and that it is 'how easy it is to move'. (Observations, family visit, April 2015)*
Disengagement	Difficulties engaging	*They [Niya's family] ask me what to do next, and I say whatever they would like. […] As we walk in, the family waits for a minute or two in the lobby. [I think unsure what to do next.] Niya does not seem very confident, so I help out and check with the cashiers what time the next 4D show is (it starts at 15.00). Niya's mum then asks me what they can do in the meantime. I tell them what is in this building. (Observations, family visit, April 2015)*

Table 3-9: Examples of coding – engagement with science during family visits

Further to looking for engagement, I also considered disengagement. This was in order to be able to examine how interactions of social axes and opportunities available within different contexts may have constrained engagement with science. Disengagement is not merely the absence of engagement for it includes acts such as giving up, boredom, withdrawal, disinterest, frustration as well as being inattentive, unprepared, distracted and mentally disengaged (Skinner et al., 2008; Skinner et al., 2009).

Once I had established the categories of the girls' engagement with science, I began exploring how interactions of gender, social class and ethnicity facilitated or constrained these. I drew on the two theoretical frameworks I outlined in Chapter 2, Bourdieu's theory of social reproduction to examine the role of social class and the interactions with ethnicity and Butler's theory of gender performativity to examine the role of gender and the interactions with social class and ethnicity. Drawing on more than one theoretical framework has been argued to be able to contribute to a higher quality of data as well as to complement so as to enable more nuanced interpretations. Burman & Parker (1993), whose work on discourse analytical approach I drew on for my data analysis, have argued for the importance of keeping the interpretative processes as open as possible:

> To introduce closure is to do violence to the variety of possible interpretations that could be given of the text when it comes to life in a discourse analytic reading (and to the variety of possible meanings which were present to those who once wrote or spoke the text). (p. 157)

Drawing on two distinct but complementary bodies of theory for examining my data helped me to consider my data in a broader way and to challenge some of the possible 'closure' of data interpretations.

Data analysis through a Bourdieusian lens

A Bourdieusian lens (1977b, 1984, 1986) enabled me to examine how the girls' engagement with science was shaped by the girls' social class and interactions with ethnicity. Coding the data through this lens meant identifying instances that I interpreted as capital (resources the girls' possessed and were able to mobilise), habitus (the girls' socialised dispositions that they internalised through past and present experiences) and field that determined the value and fit of the girls' capital and habitus. My approach to coding at this stage was deductive, meaning that I drew upon a theoretical framework in analysing my data. To code capital, I focused on what kind of resources the girls possessed, in what ways they recognised these and how valuable they were for supporting their engagement with science. For instance, I coded participants' mentioning of family members working in or studying science as a form of science-related social capital (Archer et al., 2015), e.g., Sharifa: '… my brother teaches me science, because he's a scientist really and he's at college in Edinburgh'. The girls and parents' remarks about going to museums and galleries in their free time (e.g., Cordelia's mum: 'we've always gone to museums and art galleries and things') constitute an example cultural capital (Bourdieu, 1984). I was particularly interested in cases where the capital possessed by the girls and parents had limited (perceived or actual) value within the field of school science. For example, Rifat mentioned that her dad worked as a technician (which I coded as a form of science capital), but she remarked that because her parents were from not from the UK, she rarely asked them for help with science or school in general. Hence, the capital that she had available only had limited value to her in practice.

Habitus, conceptualised as a set of internalised dispositions, was more difficult to 'pin down' in the empirical data. Concerns have previously been raised about the problematic operationalisation of this concept in empirical research. Bourdieu thought of habitus as a useful 'thinking tool', but offered little prescription about how it can be applied empirically (Davey, 2009; Reay, 2004c). Reay (2004c) has regarded habitus to be Bourdieu's most contested tool. It has previously been argued that it tends to be 'elusive and beyond observation', although arguably easier to grasp hold of when anchored to cultural capital (Davey, 2009, p. 276). To code habitus and examine how it may explain engagement patterns, I started by coding any remarks that I interpreted as indicating internalised, taken-for-granted dispositions. An example of what I coded as habitus was, for instance, was Amna's remark that it was 'common with like every parent' to want their children to get a well-paid job like a doctor or a lawyer. I interpreted this as her internalisation of this view in that she took it for granted that parents would want this for their child. I suggest that she accepted such high educational and professional aspirations as 'normal'. Further, following Davey's remark that habitus might be easier to work with empirically if linked to cultural capital, I also coded habitus (and interplay between habitus and capital) in the girls' ways of behaving.

Finally, to code the aspects of field, I focused on the norms, expectations and rules that I observed or that were articulated by the participants. This was in order to interpret how the fields were structured and to what extent they facilitated or constrained the girls' engagement with science. I coded, for example, instances where teachers and students sanctioned (interrupted, made fun of) the girls who they thought did not speak science 'properly'. I also examined the fields through the value of the girls' capital. For instance, some resources had little or no use during science lessons, but the girls were able to leverage those same resources during other occasions, such as the class visit to the science museum (e.g., singing and knowledge of pop culture). Bourdieu's concepts resonate with the arguments from students engagement literature, such as that the disposition or 'a tendency to behave a certain way' (Crick & Goldspink, 2014, p. 30) is malleable over time and across contexts (Crick, 2012). Table 3-10 shows a few examples of coding through a Bourdieusian lens.

Category	Codes (examples)	Data
Habitus	Family-related	*SG: 'Do you think it's common with Asian parents that they want their children to be doctors?' Amna: 'Yeah, I think it's common with like every parent really. It's like they want all their children to be like doctors or lawyers or something with a well-paid job, but I think most of them depend on science as well, because science gives like such a big range of like jobs and everything, I think, that's why it is like more common for people to want science related jobs.' (Interview, June 2015)*
Capital	Science capital (cultural)	*SG: 'And do you tend to do any science related activities outside the classroom?' Amna: 'Yeah, I like to do, because recently I got a science kit and it just like teaches you the structure of crystals I think ...' (Interview, June 2015)*
	Science capital (social)	*Sharifa: '… my family, like my mum, she likes science and I like science as well and all my brothers like science and my cousins and then they all did like science degrees and stuff.' (Interview, April 2015)*

Table 3-10: Examples of coding – habitus and capital

Data analysis through a Butlerian lens

Coding the data through a gender lens meant attending to discursive performances of gender. As with using a Bourdieusian lens, my intention was to explore how gender performances supported or constrained the girls' engagement with science. To analyse the data about the girls' preliminary engagement with science through a gender lens, I began by coding behaviours and discourses that included the girls' articulations about boys and girls doing science and being 'science people' as well as their discourses on the gendered nature of jobs related to science. I interpreted these discourses as being explicitly or implicitly/symbolically gendered. By explicitly gendered, I mean that the girls spoke about the gender differences in science (e.g., Cordelia mentioning that boys were more likely than girls to have a science job). In many cases, however, gender coding reflected my interpretation, in line with the extensive literature on binary gender dichotomy. This means that I labelled behaviours and discourses as symbolically gendered (Francis, 2010a; Harding, 1986). I coded gender discourses with a reference to the Western understanding of the binary gender model, whereby 'femininity and masculinity [are] linked directly to the dualist construction of sexed bodies as male and female', with 'dominant binary understandings of masculinity as rational, strong, active and femininity as emotional, weak, passive' (Francis, 2010b, p. 479). By drawing on this model, I was able to, for instance, code the girls' remarks about science being for clever students as masculine.

To analyse the girls' engagement with science in practice through a gender lens, I focused on the girls' gender performances (Butler, 1999) and gender attributes typically associated with femininity and masculinity. I acknowledge that drawing on the Western understanding of the binary gender model might risk stereotyping binary gender expressions (Francis, 2008; Phipps, 2007). Yet, I agree with other scholars that adopting such an approach is necessary to analyse and discuss what role gender play in persisting social inequalities, which continue to be demonstrated in empirical research in science and beyond (Francis & Paechter, 2015).

The challenges of coding and analysing gender involve issues around readership and interpretation, which raise questions about whose interpretations are validated (Francis, 2010b; Kessler & McKenna, 1978). Performances of gender would generally be read differently for girls than they would be for boys and these readings might further depend on one's background, such as social class and ethnicity (Francis, 2000a). Indeed, as I discussed in Chapter 2, (gendered) behaviours are always read in relation to gender attributions and the person's sexed body has implications regarding how her or his performances are understood by others (Francis, 2012). In order to make my reading of gender performances as transparent as possible and try to assure greater validity of the study, I include illustrative examples from the data in my discussion chapters, whenever possible. I coded gender performances into three categories derived from the wider education literature that I discussed in Chapter 2: hyper-heterofemininity, restrained heterofemininity and muscular intellect.

The girls' performances were not fixed, but depended on the social context. I therefore paid particular attention to the ways their performances changed from one context to another, such as in the way they performed gender differently when they were around their peers to when they were around their family (Butler, 1999; Paechter, 2003a) and what implication this had for their engagement with science. Table 3-11 provides illustrative examples of gender performances from science lessons and class visits to the science museums.

Category	Codes (examples)	Data
Performances of hyper-heterofemininity	Investment in physical appearance	*Cordelia is pretending to use the sticky tape to wax her moustache. Other students on her table giggle. (Observation, LH science lesson, March 2015)* *Caitlin tells Alimah to 'Sort your hair out girl!' (Observation, NS class visit, November 2014)*
	Flirting with boys	*Aliyah stops to talk to Caitlin who complains that she hurt herself when she was chasing the boys in their game of tag. (Observation, NS class visit, November 2014)*
	'Selfies'	*Aliyah says 'I took a selfie with the boy I like' – has to repeat this a couple of times as Caitlin is distracted by the other exhibits. 'Let's take a selfie' Aliyah, Caitlin says – 'I'm going to post it to Instagram'. (Observation, NS class visit, November 2014)*
Performances of restrained heterofemininity	Quiet and passive	*Dorota on table 2, who is quietly writing something down in her notebook, seems on task. (Observation, LH science lesson, March 2015)* *Sharifa is quiet and has not spoken a word to anyone since the start of the class. (Observation, NS science lesson, July 2015)*
Performances of muscular intellect	Showing off knowledge	*Mr Bramley tells them that scientists would use chromatography to solve the crime. Dorota explains to Nicole what chromatography is. (Observation, LH science lesson, June 2015)*
	Confident participation	*[Male name], [male name] and Samira keep their hands up most of the time. Mr Cohen keeps telling them to put their hands down and give others a chance too. (Observation, NS science lesson, November 2014)*

Table 3-11: Examples of coding – gender performances

Structure of this thesis

The structure of this thesis reflects three aspects of the study: (i) the different 'types' of engagement with science, including preliminary engagement with science and engagement with science in practice; (ii) the social contexts where the girls were observed engaging with science in practice, including science class and family; and (iii) the theoretical lenses used to analyse the data. This thesis includes four analysis and discussion chapters, as presented in Table 3-12.

	Chapter 4	**Chapter 5**	**Chapter 6**	**Chapter 7**
Engagement with science	Preliminary	In practice	Preliminary and in practice	In practice
Social context	-	Science class	Science class	Family
Physical setting	-	Science classroom and science museum	Science classroom and science museum	Science museum
Theoretical lens	Bourdieusian	Bourdieusian	Butlerian	Bourdieusian and Butlerian

Table 3-12: Structure of the thesis

As evident from the table, Chapter 4 examines the girls' preliminary engagement with science through a Bourdieusian lens. Chapter 5 explores the girls' engagement with science in practice during science lessons and class visits to the science museum through a Bourdieusian lens. Chapter 6 explores the girls' preliminary engagement with science and engagement with science in practice during science lessons and class visits to the science museum also through a Butlerian lens. Finally, Chapter 7 examines the girls' engagement during family visits through both theoretical lenses.

Writing up

Analysing and making sense of my data involved a series of spread sheets and mind maps, which I used to look for patterns and explanations. Alongside these approaches, I also started writing up my findings soon after completing my pilot study and continued with the writing throughout my data collection. Unsurprisingly, none of the early writings made it into the final thesis in their original form. However, I saw the writing process as crucial for thinking about my data, or to adopt the words from Punch (2009, p. 341), I was 'writing to think' and understand the data. Continuous writing helped me construct my ideas and restructuring, reworking and rewriting my arguments a number of times helped to form those that are presented in this thesis. Writing was therefore closely interlinked with data analysis. I followed Kvale and Brinkman's (2009) advice and attempted to play devil's advocate towards my own findings, in order to consider alternative explanations. This was also done through discussing my research with other scholars within and outside science education, such as at conferences, summer schools and seminars[9], where I invited scrutiny of my emerging findings.

In preparing the final version of this thesis, I was concerned about giving the research participants an honest representation and presenting a work that is of high research quality. I kept in mind that it was ultimately me who would 'cut and paste' the narrative together (Fontana & Frey, 2000, p. 697; Reay, 1996b). This meant that it was my decision what part of the data and which quotes to include in the final study. I argue that the validity of my findings can be judged 'on the basis of the adequacy of the evidence offered in support of the phenomena being described' (Lewis et al., 2014, p. 359). Accordingly, I grounded my claims and explanations in empirical evidence, by providing quotations and field notes (with reference details including the month and year when the data were collected), to show as much as possible the procedures that have led to my conclusions (Miles & Huberman, 1994).

In this thesis, I mostly write in the first-person and use an active voice, which Patton (2002) has argued 'communicates the inquirer's self-aware role in the inquiry' (p. 65) and indicates researchers' reflexivity practices. The use of the active first-person voice is in line with my position that social knowledge is not an objective truth, but rather, it is co-constructed through the research process in

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[9] During my doctoral studies, I presented my research work at the European Science Education Research Association (ESERA) Summer School 2014 in Nevşehir, British Educational Research Association (BERA) Conference 2014 in London, National Association for Research in Science Teaching (NARST) Conference 2015 in Chicago, ECSITE Conference 2015 in Trento, ESERA Conference 2015 in Helsinki and the Gender & STEM Conference 2016 in Newcastle.

which I played an active part. The first-person active voice projects a sense of subjectivity and researcher's involvement in the research project, and therefore, I consider it appropriate and even necessary to use in my thesis.

3.6 Ethical considerations

For this study, I followed the professional codes of conduct specified by the British Sociological Association (BSA, 2002) and the British Educational Research Association (BERA, 2011). The study has received the ethical approval from the Research Ethics Panel at King's College London (Reference number: REP/13/14-1, see Appendix 1). Following the BSA and BERA guidelines, the nature of the research was made clear to the participants, who were informed that their participation was voluntary and that they could withdraw from the research at any point without having to provide an explanation. Whilst students were involved in the project activities as part of their regular science lessons, their participation in the research was voluntary. This study did not involve vulnerable adults or children, and all participants had the capacity to give their own informed written consent to participate. As my participants were under the age of 16, I sought their parents' consent as well as their own. The participants were also informed about the procedures that they could follow, if they believed that they have been harmed through their participation in the project. I respected the anonymity and privacy of research participants as well as assuring data confidentiality. To protect the participants, I anonymised all of the names of the participants at the point of transcription. After the transcripts were returned from the external transcriber I gave all my participants pseudonyms. I also gave pseudonyms to the two schools. I decided to leave out some more specific descriptions relating to the schools, as the precise data might mean that the schools can be identified. I refer to the two science museums visited simply as 'science museums', to ensure that the focus stays on the generic experiences of schools and museums rather than the impact of a specific institution.

3.7 Summary

In this chapter, I have presented and discussed my methodological approach to addressing the research questions. This study involved employing a social constructionist approach and qualitative research methodology, which enabled an in-depth examination of how interactions of gender, social class and ethnicity shape girls' engagement with science. To address my proposed research questions, I recruited 15 girls from two urban secondary schools in London and Manchester, who participated in a series of project activities during the academic year 2014-2015. To gain further insights into the girls' engagement with science, I also recruited their parents (n=10) and their science teachers (n=4).

I collected data using multiple methods of data collection: focus groups, interviews and observations. This enabled me to gain an understanding of the processes and influences shaping the girls' engagement with science as well as contributing to methodological triangulation in order to increase validity and reliability of my findings. To analyse the data I collected, I began by coding and mapping out the girls' preliminary engagement with science and engagement with science in practice, which I then examined through two theoretical lenses, Bourdieu's theory of social reproduction and Butler's theory of gender performativity. I argued that, together, these two theoretical frameworks helped me unpack the complexity and more fully understand how social axes shaped the participating girls' engagement with science. In the following four chapters, I present and discuss the findings of this study.

Chapter 4: Girls' preliminary engagement with science: A Bourdieusian analysis of the role of family and school

4.1 Introduction

In this chapter, I discuss the analysis of the girls' preliminary engagement with science through a Bourdieusian theoretical lens and lay the foundations for the analyses of engagement with science in practice that I discuss in the later chapters. Specifically, I examine how the girls' experiences and resources influenced their preliminary engagement with science and gave them different starting points for engaging with science during the activities I observed. I begin to address my first research question: **How do interactions of gender, social class and ethnicity shape girls' preliminary engagement with science?** I draw on the data from focus groups and interviews with all study participants.

I begin the chapter by outlining the typology of the girls' preliminary engagement with science. I then discuss how this was influenced by their past and present experiences within the family and school, through focusing on the interactions between habitus and field. Subsequently, I explore what capital the girls possessed, how they were able to mobilise it and in what ways these resources shaped their preliminary engagement with science. I conclude the chapter by discussing the usefulness of Bourdieusian theory for analysing the girls' preliminary engagement with science.

4.2 Typology of the girls' preliminary engagement with science

My analysis generated five categories of the girls' preliminary engagement with science: strong, partial-problematic, partial-pragmatic, partial-selected preliminary engagement with science and dis-identification with science (see Table 3-6). This typology maps out the girls' identification with science and their aspirations, as previous studies have suggested that these parameters were particularly important for understanding young people's engagement with science and their participation in science in the future (Archer et al., 2015; Calabrese Barton & Tan, 2010).

I interpreted two girls' preliminary engagement with science as **strong**. Samira and Dorota spoke about identifying with science and both remarked that key adults in their lives recognised them as 'scientific'. Dorota mentioned that teachers at her school called her 'little Einstein'. Samira noted that her mum always praised her for her science achievements and was confident that Samira would continue studying science at Oxford University, which I interpreted as mum recognising her as being a 'science person'. Both girls aspired to having science-related careers. Dorota wanted to work in medicine or, alternatively, in astronomy and Samira aspired to working as a research scientist. Samira and Dorota were high-achieving science students, who reported enjoying science in and outside of school, on their own and (when rare opportunities arose) with their families. They explained their identification with science with intrinsic reasons, such as relating it to their interest in science (Samira) and their curiosity about and 'love' of science (Dorota).

I categorised Hayley's preliminary engagement with science as **partial-problematic**. Like Dorota and Samira, she aspired to having a science-related career as a research scientist. However, despite reporting being interested in science and wanting to study it in the future, Hayley did not consider herself to be 'scientific'. When asked to elaborate, she mentioned that she was often told off in science lessons for talking, suggesting that 'science people' would not behave in such ways. She also mentioned that her mum was surprised when she found out she was interested in and doing well in science. In a teacher interview, Ms Richards speculated that Hayley seemed too 'cool' to want to be seen as being into science. Hayley spoke about often participating in science-related activities outside school on her own, such as through reading about science online. At the time of the study, she was also preparing an interactive science exhibit for the school's science fair. I suggest that challenges in terms of being recognised as 'scientific' may have contributed to Hayley's doubts as to whether she was a 'science person', which is why I labelled her preliminary engagement with science as 'problematic'.

I labelled three girls' preliminary engagement with science as **partial-pragmatic**. Sharifa, Amna and Asqa reported identifying with science and aspiring to have science-related jobs. Unlike Dorota and Samira, however, these girls predominantly associated their identification with science with more pragmatic or extrinsic reasons, such as wanting to pursue respectable science-related professions and science being 'normalised' within their family. The girls in this category were unsure about how other people saw them in terms of being 'scientific'. Unlike the above three girls, Sharifa, Amna and Asqa rarely participated in science-related activities outside school. They were all of South Asian Muslim origin (Pakistani and Bangladeshi) and related their dispositions towards science to the high value of science-related professions like medicine within their ethnic communities.

I categorised four girls' preliminary engagement with science as **partial-selected**. Aliyah, Cordelia, Rifat and Layla did not see themselves as 'science people', although they spoke about having science-related aspirations. Two aspired to joining the medical profession and two wanted to become games designers. Their relationship with science appeared to be complex, in that they made a distinction about some form of science being more for them than others. Cordelia, Rifat and Layla indicated the gendered nature of their preliminary engagement with science, through identifying with 'feminine' science (such as biology), but rejecting identification with other areas of science that have been traditionally constructed as masculine. Cordelia and Layla also aspired to having traditionally female occupations in healthcare (Francis, 2002; Francis, Hutchings, Archer, & Melling, 2003). These girls also reported rarely or never participating in science-related activities outside school.

Finally, the remaining five girls **dis-identified** with science. Alimah, Caitlin, Jasmine, Larisa and Niya had little or no interest in it and appeared to be antagonistic towards school science and science in general. These girls spoke about not seeing themselves as 'scientific' and science did not feature their primary career aspirations. Alimah, Caitlin and Jasmine aspired to working in the entertainment industry as singers or actresses, whilst Larisa and Niya aspired to having jobs in the arts (as an author and an interior designer, respectively). Alimah and Caitlin had a secondary aspiration that was science-related; Alimah mentioned possibly wanting to become a doctor (although mostly to appease her dad) and Catlin said she might work with animals, perhaps as a vet. Despite these plans, the two girls both said they planned to drop science subjects as soon as possible.

4.3 Interaction of habitus and field: Family

In this section, I discuss the role of family in shaping the girls' preliminary engagement with science. According to Bourdieu, family and social background play a key role in structuring children's habitus through the process of primary socialisation (Bourdieu, 1984; Bourdieu & Passeron, 1990). Habitus informs what children consider thinkable and possible for them, in general and in relation to science (Archer, Hollingworth, et al., 2007; Bourdieu & Passeron, 1990; Willis, 1977). As Nash (1990) has put it, 'people do what they have been brought up to do' (p. 442). Previous science education studies have argued that family plays an important role in influencing children's engagement with science (Adamuti-Trache & Andres, 2008; Archer et al., 2012b; DeWitt, Osborne, et al., 2011; Gilmartin et al., 2006; B. Wong, 2012). I contribute to this body of knowledge by showing what role the family played for the girls from working class and ethnic minority backgrounds.

Most of the girls in this study were working class, based on the data available about their parents' education and occupation (see Table 3-1). Only one girl mentioned a parent who had completed a university degree and was at the time of the study employed in a job that aligned with this qualification (Amna's mum worked as a primary school teacher). I therefore contend that only one girl could be labelled as middle class. As I discussed in Chapters 2 and 3, determining social class is generally problematic and made even more precarious when mediated by ethnicity and the context of migration, as a recent history of migration can contribute to downward social mobility. People previously considered middle class in their country of origin may 'become' working class in the country of settlement (Erel, 2010; Modood, 2004; Platt, 2005). In this study, 13 out of 15 girls had one or both parents born outside of the UK and two girls were born abroad themselves.

Several of the girls' parents held middle class jobs in the country of origin, but did not resume comparable employment in the UK. For instance, Sharifa's mum used to be a science teacher and the deputy head of a school in Pakistan, but had been unemployed since arriving in the UK over a decade ago. My aim was not to unambiguously determine the participants' social class (hence class labels should be considered as indicative), but rather, explore how familial social disadvantage may have influenced the girls' educational and science trajectories.

Working class habitus and science aspirations

The data suggest that despite working class families seemingly dominating the cohort, only three girls appeared to have typically working class habitus in Bourdieu's sense. That is, only three of the girls and their parents spoke about attitudes towards educational trajectories in ways that I interpreted as aligned with working class habitus (Bourdieu & Passeron, 1990; Reay, 1998a, 2001a). This was evident, first of all, in parents playing a limited role in their daughters' education and, instead, letting them make their own decisions. These parents appeared to have little or no expectations about their daughters' future educational and professional trajectories. Aliyah, for instance, said that she never talked to her parents about what she might want to study or do in the future. She speculated that 'they would probably just say be whatever you want to be'. Jasmine's dad, similarly, emphasised the importance of his daughter making her own decisions about her future, 'I'm going to let her just develop, you know'. These parents appeared to prioritise processes over outcomes. They wanted their daughters to, most of all, enjoy their educational experiences. Jasmine's dad emphasised that it was important for her to find 'stuff she enjoys' by herself, mentioning sport and music as examples of activities she liked doing at the time and that she may take up in the future. This approach was reminiscent of what Lareau (2003) has called 'the accomplishment of natural growth', typical of many working class parents who put at the forefront their children's 'natural' development over trying to influence their future trajectories more actively (like middle class families tend to).

These girls and families' working class habitus was also evident in their remarks about not seeing higher education (and science) as 'for them'. Parents spoke unfavourably about going to university and suggested that such trajectories may not be well-suited to their daughters, nor necessary the best way for their daughters to have a 'successful' life (Reay & Ball, 1998). Caitlin's mum was particularly exemplary of working class attitudes towards education. She had low expectations of her daughter in terms of her academic achievement, remarking on being 'really surprised' when Caitlin recently received good grades. She thought that it was unlikely that Caitlin would go to university and expressed worries that if she did, she could 'only be stuck for a couple of years doing something that makes her miserable'. No one in their extended family had ever finished a university degree, although Caitlin mentioned that 'a couple of [mum's] cousins went to university and dropped out'. Higher education appeared to be constructed as a risky and uncomfortable place, which was not a 'natural' or expected option for her. This way of thinking resonates with the working class tendency to 'not push their luck' (Nash, 1990), but rather accept 'a sense of one's place' in society (Bourdieu, 1984). As previous work has observed, feelings of anxiety and ambivalence of many working class children in relation to middle class institutions, like universities, might contribute to an act of self-elimination (Bourdieu & Passeron, 1990; Reay & Ball, 1997). Reay (2004c) has also noted that habitus 'predisposes individuals towards certain ways of behaving ... As a result, the most improbable practices are rejected as unthinkable, but, concomitantly, only a limited range of practices are possible' (p. 433).

With higher education largely being framed as unthinkable, non-academic aspirations appeared to be more desirable among these girls. Jasmine and Caitlin both aspired to celebrity careers as actresses or singers, which literature has regarded to be a typically working class aspiration (K. Allen, 2011; Walkerdine, 1990). However, this is not to say that all celebrity aspirations are necessarily aligned with working classness (K. Allen & Mendick, 2013). Walkerdine (1990) has noted that fame may be perceived by working class girls as offering 'a possibility of a talent from which they have not automatically been excluded by virtue of their supposed lack of intelligence or culture' (p. 50). With a perceived risk and anxiety (even 'misery') associated with going to university, becoming a celebrity was perceived as a more attainable aspiration for white working class girls like Caitlin. In contrast to the middle class families I discuss below, parents like Caitlin's mum did not see higher education as a necessary route to doing well in life, but instead actively encouraged aspirations like singing and acting. Her mum, for instance, spoke approvingly about Caitlin's older sister wanting to become a 'female Simon Cowell[10]' and commented: 'as long as she buys me a house, if she makes that much money, I don't care [what she chooses to do]'.

Not surprisingly, science played a peripheral role in these families' lives and in the girls' aspirations. At least this was the case with Jasmine and Caitlin. Aliyah wanted to be a games designer, although she knew little about what it would take to achieve this and kept changing her mind between designing games or perhaps 'just selling games' at the local games arcade. Jasmine and Caitlin had little interest in science themselves and low science capital in the immediate or extended family to draw upon (see section 4.5 for a discussion on science capital). Science, as previous work has highlighted, tends to be seen as a high status aspiration, more commonly normalised among middle class children and their families (Archer et al., 2012b; Francis, 2000b). Jasmine and Caitlin's parents did not consider science as a possible or likely route for their daughters, although in line with giving them the freedom to choose whatever they liked, Jasmine's dad said that he 'wouldn't put it past her [Jasmine]' to choose science. Caitlin's mum, on the other hand, admitted that she struggled to imagine Caitlin doing anything science-related despite also commenting that science was one of her best subjects. She only saw Caitlin as being

[10] Simon Cowell is an English reality television judge, entrepreneur, philanthropist and TV producer. He is most recognised as a judge on the British TV talent competition series, including The X Factor and Britain's Got Talent (Source: Wikipedia).

involved in science as part of more a thinkable career path in the entertainment industry, to which Caitlin also reported aspiring.

> Caitlin's mum: 'I should remember the name of the show, … the Big Bang Theory, yeah, if she could be on something like that then she would [do something science-related], but as a day to day job in her life, no.' (Interview, February 2015)

I suggest that Caitlin's mum's attitudes to education and science could have dissuaded Caitlin from developing an identity in science in that she has internalised her mum's views that higher education and science were not for her. While Caitlin said she enjoyed doing science, this did not translate into her seeing herself as someone who would do science. Similar findings on the disjuncture between 'doing' and 'being' in science have previously been highlighted by Archer and her colleagues (2010, 2012b), who have argued that while many young people reported that they enjoyed doing science, they did not see themselves as 'science people' or aspired to doing science long term.

Responsive habitus and the role of ethnicity

The majority of the girls in the study (12/15) spoke about family expectations and attitudes to education that have typically been associated with the middle class (Ball, Davies, David, & Reay, 2002; Bourdieu & Passeron, 1990). Middle class family attitudes to education were evident in the high educational and occupational expectations that parents had for their daughters. These families expected their daughters to go to university, as reported by either the girls or the parents themselves. Going to university appeared to be a 'non-choice' (Reay, 1998a; Reay, David, & Ball, 2005). The following excerpt from an interview with Larisa's mum illustrates such high parental expectations in relation to education.

> Larisa's mum: 'She's definitely going to university, definitely, but we don't know which subjects she will be choosing.' (Interview, May 2015)

The quote suggests that Larisa and her mum would be deciding together which subjects Larisa would study. In addition, the plan for Larisa to go to university was stated as not open for debate. I interpreted Larisa's mum attitudes to education (and the notion that a child's education was a 'family project') as aligned with dominantly middle class values and expectations. Typically middle class attitudes to education were also evident in parents' remarks about closely supporting and monitoring their daughters' education. As the following quote from Niya's dad suggests, he was very involved in monitoring his children's schoolwork.

> Niya's dad: 'You know, I'm strict with this, keep telling them to check their homework and study. I give them time for play as well, not a problem … but their studies, they must have time for study and they must complete their homework.' (Interview, May 2015)

The focus on academic attainment and strong parental involvement in their children's schools stands in contrast to the above discussed typically working class approach to education, where parents focused on their children enjoying the schooling experience and protecting them from potential failure.

Such family attitudes that aligned with middle class values were, therefore, not reproductive in the Bourdieusian sense. That is, they did not reproduce the patterns typical for 'people like them' in a sense of aspiring to working class jobs that their parents were doing. The families spoke about expecting their children to have better lives than they had and they saw education as a path to achieving social mobility (Francis & Archer, 2005; Modood, 2004). Larisa's mum expected and encouraged her daughter to go to university despite herself not having attended higher education. She migrated to the UK from Latvia in her early 20s after Larisa was born. At the time of the study, she was working as a cleaner. Dorota's mum, similarly, aspired for her daughter to improve her social situation, to 'get a good job and have a better life after'. Her mum, like most parents in this study, was a first generation migrant in the UK, who hoped that her children would have an easier and better life than she did. Several parents mentioned not having opportunities in their countries of origin to study, at least not to the extent these opportunities appeared to be available in the UK. Education literature has previously discussed that some parents' desire for their children to achieve academically reflects their own lack of educational opportunities, which fuels their ambition for their children (Basit, 2013).

These families' attitudes were responsive to the current disadvantaged situation and were aspirational in the sense that there was an ambition for improvement. It has been argued that high family expectations for their children tend to be particularly common among some ethnic minority groups, who have a 'habitus in which the expectation of mobility forms a central narrative' (Archer & Francis, 2006, p. 42). There are some parallels between the responsive habitus I discuss here and what Reay (2004c) has previously called 'transformative habitus'. The common idea is that habitus can change. However, Reay's transformative habitus was grounded in the notion that students 'changed' their habitus in response to direct exposure to a particular field, such as an elite educational institution (i.e., when working class students encounter a middle class field of higher education). Responsive habitus, on the other hand, comes from the family and is driven by the ambition to change a current disadvantaged social position, but without necessarily being exposed to or having encountered a field that played a role in shaping this habitus.

The girls and their parents related their ethnic background to shaping not only high educational aspirations generally, but also in science more specifically. This was most notable in the case of six South Asian and two Middle Eastern girls. For example, Sharifa said that Asian parents 'want you to get a good job and succeed and stuff', such as through becoming a doctor or a scientist and Asqa, similarly, said that her parents wanted her 'to have a good job … They want us to do something of our own choice, but something that will get us, like, well off'. Careers in medicine were especially popular, as previous studies have found to be the case among many South Asian students in the UK (Springate, Harland, Lord, & Wilkin, 2008). The parents from South Asian and Middle Eastern backgrounds explicitly articulated careers in science as being particularly desirable within their ethnic communities.

> Samira's mum: 'Most Arabic people, they turn into pharmacists or doctors, so it's very strong with our friends and family. All our friends, all the Iraqis also Arabs and Muslims, put emphasis on knowledge and learning.' (Interview, December 2014)

A previous study of young Pakistanis in the UK has argued that parents have a habitus that values education regardless of their own education or background (Shah et al., 2010). Another study has identified 'Asian' students as having particularly favourable dispositions (expectations, attitudes and behaviours) that supported their engagement with science (DeWitt, Archer, et al., 2011).

The teachers also noticed the high expectations of the South Asian parents. Ms Richards remarked that there was 'a lot of pressure from the [Asian] parents' for their children to do well at school. Mr Bell observed that the pressure within South Asian communities may have been even stronger for girls than it was for boys, who 'seem to be allowed to make their decision a little bit more, like what they want to do, rather than girls, especially Asian girls, seem to be kind of like maybe doing science, you're doing this, you need to do this'. Parental pressure for high attainment, with a focus on science, might at least partly explain the dispositions of some of the girls' to engage with science. All three pragmatically identifying girls, for instance, were from South Asian families and stressed strong family support and push towards science.

The family aspirations and attitudes towards education were internalised by the girls, who spoke about such parental expectations as 'normal'. For Bourdieu, habitus operates not on a conscious level, but rather, as internalised dispositions (Bourdieu & Wacquant, 1992). Modood (2004) has proposed that the way parents get their children to internalise high educational aspirations works as a 'motor' for upward social mobility of many minority ethnic students. Asqa, for instance, commented that she was able to choose whatever she wanted to pursue, 'they're more like you can choose whatever you want, they don't force us or anything'. Yet, she appeared to have simultaneously internalised the values she ascribed to her parents and aspired to having a career in medicine, which she considered to be well regarded within her family and the wider ethnic community. Amna, further, saw her parents' attitudes and aspirations for her as typical of 'every parent', suggesting the taken-for-granted nature of her habitus in terms of valuing education and science.

> Amna: 'I think it's common with like every parent really, it's like they want all their children to be like doctors or lawyers or something with a well-paid job, but I think most of them depend on science as well, because science gives, like, such a big range of, like, jobs and everything.' (Interview, June 2015)

Parental attitudes were transmitted and internalised by the girls also through the feelings of pride, as Asqa's quote illustrates.

> Asqa: '… my parents like all these Asian parents, they want you to be either a doctor, a lawyer or an engineer, there are the three options, because they want to feel proud that they have a son or daughter like that.' (Interview, June 2015)

Shah et al. (2010) have previously argued that Pakistani students in their study 'were acutely aware of the respect and status higher education and professional qualifications would confer on the family' (p. 1114). Other studies have highlighted the importance of academic qualifications for social prestige (Ahmad, 2001). Asqa commented that her parents liked to boast about their children's academic achievements to members of the Pakistani community (Asqa: 'It'll be like, oh, my child, she's so good, look!'). This suggests that the child might be seen as the 'face' of the family, as studies have argued is the case within the Chinese community in the UK (Archer & Francis, 2006).

Parental encouragement for science was in some cases mixed with hesitancy as to what they considered to be realistically possible for their daughters. The girls reported receiving conflicting messages. Rifat's case is particularly exemplary of a disjuncture between receiving support and encouragement for science, on the one hand, and warnings that careers like medicine may be too demanding for her, on the other. This, in turn, seemed to have affected her confidence and ultimately her aspiration, as the following quote suggests.

> Rifat: 'I used to want to be a doctor, but my mum was like "that's a lot of work, you need to be really good in maths and science", then I was like, "fine I'll think of something else".' (Focus group, June 2014)

Despite her parents favouring science among the school subjects (e.g., Rifat spoke about how her parents encouraged her to study science and helped her with science more than they did with other subjects), Rifat also conveyed a sense of insecurity about whether she was capable of studying a demanding science course. This was despite saying that she understood everything they were learning in science. Along with the positive attitudes towards science, she appeared to have internalised a sense of inferiority. She mentioned not feeling good enough to study medicine despite having good grades, which I suggest might constrain her opportunities and what she thought was possible and achievable for her. The tension between desirability and perceived achievability of demanding career trajectories, along with the low levels of capital available to support them (see section 4.5), is likely to compromise her long-term outcomes (Archer et al., 2012b; DeWitt, Archer, et al., 2011).

4.4 Interaction of habitus and field: School

In this section, I discuss how the girls' preliminary engagement with science was shaped by their experiences at school. According to Bourdieu, primary socialisation happens within the family and experiences at school add an important layer to it (Bourdieu, 1967). People's habitus is 'permeable and responsive to what is going on around them' (Reay, 2004c, p. 434). Bourdieu (1967) has called school 'a habitus-forming force' and has argued that it can provide a general disposition, which he has termed 'cultured habitus'.

> The habitus acquired in the family is at the basis of the structuring of school experiences …; the habitus transformed by the action of the school, itself diversified, is in turn at the basis of all subsequent experiences … and so on, from restructuring to restructuring. (Bourdieu 1972, p. 188, translated in Bourdieu & Wacquant, 1992, p. 134)

I examine the data in the light of the norms and values of school as dominantly aligned with middle class (Bourdieu & Passeron, 1990). School has been argued to be a 'culturally alien setting' for students from socially disadvantaged backgrounds (Nash, 1990, p. 435). I anticipated that school science, which has been contended to reflect the norms and practices of dominant social groups and the scientific elite, might present a particularly alien setting for many students from lower socioeconomic and ethnically diverse backgrounds (Claussen & Osborne, 2013; Lemke, 1990). Given that most of the girls in this study rarely or never did any science-related activities outside school, I suggest that their school experiences may have played a particularly important role in shaping their ideas about science. School was a key setting where these girls (knowingly, at least) encountered science and science-related practices and I posit that their experiences significantly shaped their views about for whom science was intended and what it meant to be a 'good' science student.

For many of the girls in this study, science was indeed synonymous with school science. This was particularly notable among the girls who did not identify with science. The five science-identifying girls articulated broader views of what science entailed, which I discuss in relation to science capital in the next section. Among the girls who did not identify with science, Caitlin mentioned that it was about 'gases and solids', Aliyah related it to 'being in a lab' and Larisa spoke about it in relation to 'chemicals' and the 'pH scale'. I acknowledge that the girls' answers may have been shaped by the physical settings in which the data were collected (i.e., all the student focus groups and interviews sessions took place at the girls' schools). However, the difference within the cohort suggests that these perceptions were mediated by other factors and not all of the participating girls constructed science as being aligned with the school subject. Unsurprisingly, the girls who spoke about science mostly in terms of school science tended to see it as less relevant for their current and future lives.

The participating science teachers echoed the view that for many students, science seemed to be equated with the topics and experiences they encountered in the classroom. Mr Bramley mentioned that teachers often struggled 'to actually get out of the [classroom] situation' and show students that science exists outside the science lab: 'this is science, this is real science, this is where science happens, not in a classroom, in the whole, in the museum, in industry, you know'. Mr Bramley's reflections mirror previous findings that science curriculum often fails to help students see the breadth of science (Braund & Reiss, 2006; Osborne & Dillon, 2008) and that school science struggles to engage with students' wider cultural contexts and values (Claussen & Osborne, 2013).

Experiences in the science lessons appeared to have shaped the girls' ideas about what it meant to be a 'science person'. For instance, in line with what previous studies have argued (Archer et al., 2010; Harding, 1986), the girls described 'science people' as 'clever', well-behaved, good explainers and confident in class. The following data from a focus group at Northfields School illustrates how the girls spoke about their (white, middle class, male) classmate, who they unanimously considered to be emblematic of a 'science person' in their class.

> Samira: 'He can work out things like really fast. He's like a calculator and a dictionary put in one.'
> Alimah: 'He always gets the answer.'
> Caitlin: 'I know everybody, like, says this, but I'd have to say, like [male name], because he's so smart, yeah, because, like, he's smart and he's into like physics as well.' (Focus group, November 2014)

The descriptors of the celebrated position of 'science people' within the science classroom parallels findings of previous research, which also raised concerns that this position was difficult for many students to align with (Carlone et al., 2014; DeWitt, Archer, & Osborne, 2012; Shanahan & Nieswandt, 2011; Varelas et al., 2011). Other girls in this study spoke about 'science people' in terms of practices, such as they had to like 'reading books' (Niya) and were good at explaining things (Larisa). From a Bourdieusian perspective, I interpreted these features as forms of middle class (embodied) cultural capital/dispositions (Bourdieu, 1984), against which some girls seemed to have positioned themselves at a distance. Rifat's quote below suggests a sense of inadequacy in the science classroom. Despite doing well at science, she did not see herself as being good enough at it.

> Rifat: 'I'm not a science person, but I enjoy it. Because I'm OK at science, but I'm not that good. I can understand everything, but yeah …' (Focus group, June 2014)

Rifat's internalised sense of inferiority and not being good enough to undertake a more demanding science course was shaped by the interplay of her experiences within home and school (see above). I suggest that further to her mum projecting her views that a career in medicine might be too difficult for her, Rifat's school experiences appeared to have further problematised her preliminary engagement with science.

The descriptions of 'science people' given by the girls fitted with the notion of an 'ideal student' as outlined by Archer & Francis (2007). They described an 'ideal student' as 'naturally' talented, active and 'outside culture', arguing that this position was easiest to occupy for white middle class male students (see Chapter 6 for the discussion of the data through a gender lens). Following Bourdieu's argument, the male classmate that the Northfields School girls pointed to as exemplifying a 'science person' in their class could be seen as 'ready' for schooling (Nash, 1990). I suggest that he was also 'ready' for school science and thus privileged within the field. The girls seemed to be aware of what behaviours were celebrated in the science classroom. Recognition in the classroom was a part of the habitus shaping experiences, as the girls internalised what behaviours and resources were valuable within the field. The above descriptions of their male classmate, I suggest, could have influenced their ideas about what 'science people' are or should be like.

The girls who perceived their behaviours as in tension with the expectations of the science classroom tended to suggest that science was not for them. I interpreted the behaviours that they were referring to, such as chatting to their friends and not always listening to the teachers, as being in tension with middle class dispositions valued by school. Several girls who struggled to see themselves as 'science people' mentioned that despite enjoying science, they were not the 'good science student' they thought they ought to be. As aforementioned, Hayley, for instance, who aspired to being a research scientist and often did science-related activities outside school, admitted that she often got 'told off for talking' in science classes, which she saw as in conflict with being a 'good' science student. Bourdieu

(1974) may have explained this through the idea that non-dominant/working class students take 'refuge in a kind of negative withdrawal which upsets teachers' (p. 41). Cordelia's case, similarly, illustrates tensions between the field of school science (with its norms, expectations and structures of power) and her own habitus. She recalled receiving an explicit message that she was not the sort of student who would do science. She recalled Ms Richards telling her off one day, saying that science did not particularly 'like her'. Cordelia found this upsetting: 'How can she speak for science? Science might love me!'. This further suggests that behaviours that did not easily fit with the science classroom expectations received direct or indirect responses that they were in tension with being 'scientific'. I discuss examples of how this played out in practice (during observations) in Chapter 5.

Dispositions that make up the habitus are a product of opportunities and constraints that people experience throughout their lives (Bourdieu, 1990b; Reay, 2004c). Family and school experiences, as I demonstrated in this and the previous section, contributed to the girls' internalisation of what was desirable, thinkable and possible for 'girls like them' to aspire to, what it meant to be a 'science person' and to what extent this may have disposed them to engage with science in practice. Preliminary engagement with science was also supported by the resources (capital) that the girls had available and the extent to which they were able to recognise and realise these resources, which I turn to next.

4.5 Science, cultural and social capital

In this section, I discuss how the girls' science, cultural and social capital contributed to shaping their preliminary engagement with science. I examine what capital the girls had available to them, if/how they recognised and mobilised it (Anthias, 2007; Skeggs, 2004c) and how their science capital, through interactions with habitus, influenced their preliminary engagement with science. While the girls in this study were mostly from working class backgrounds, as I discussed above, and possessed relatively little dominantly valued capital, there were notable differences regarding the amount of capital they possessed and the extent to which they were able to deploy it.

Science capital and the girls' identification with science

There appeared to be a difference between the girls who identified with science and those who did not in terms of their attitudes towards it and their views about transferability of science skills and knowledge. The girls who reported identifying with science spoke about more positive attitudes towards it, viewing science as more useful and relevant for life outside the science classroom. All of the girls who identified with science and aspired to having science-related careers (n=5) had relatively broad views about what science entailed and why it was a useful subject to study. Samira and Dorota spoke about the value of science for everyday life as well as for careers. They expressed the view that 'science is everywhere'. Dorota, for instance, mentioned that science was 'very useful for like, cooking, washing up' and 'where to store certain foods, because of bacteria'. Finding science personally valuable and useful for lives outside school was previously found to positively correlate with students' attitudes to and engagement with it (Ainley & Ainley, 2011; Calabrese Barton, 1998). Seeing science as useful and valuable was in itself a form of science capital (Archer et al., 2015; Claussen & Osborne, 2013). The girls I categorised as having a partial-pragmatic preliminary engagement with science saw the subject as useful predominantly for extrinsic reasons. Asqa spoke about needing science to become a doctor and Amna stressed the importance of science A levels for her future. They saw science useful for their future, which had positive implications for how they identified with it. This finding is also important, because a previous study has found that the extent to which students think physics and mathematics are useful for their future career predicts the rate of their choosing these subjects post-16 (Mujtaba & Reiss, 2014).

The girls who did not identify with science appeared to have narrower ideas about what science entailed and how useful it was outside the classroom. For instance, Caitlin said that she was 'not really sure that you can use any of the science we're learning [at school] in everyday life' and struggled to see the connection between science and popular aspirations like medicine, 'I don't know, I think everybody says that they'd like to be a doctor but in no way possible does this have anything to do with science'. The latter statement provides some explanation for why Caitlin was considering dropping science subjects as soon as the opportunity arose despite also mentioning that she was contemplating becoming a vet if her singing/acting career did not work out. Young people's narrow views about what science entails and how useful it is for varied educational and professional trajectories have been a concern of many previous studies, which have associated these with low engagement with science (Osborne & Collins, 2001; Osborne et al., 2003).

The girls in this study had a low amount of science capital available within their immediate families, which shaped their preliminary engagement with the subject. Being from a 'science family', as previous studies have found (Adamuti-Trache & Andres, 2008; Gilmartin et al., 2006; Lyons, 2006), appeared to have played an important role. Two girls made particularly explicit links between parental science capital/occupation and their own identification with science. Having little or no science capital within the family appeared to have swayed Cordelia's identification with science away from it. Cordelia speculated that 'science people' came from families who are involved with science, which hers was not.

> SG: 'What would you say makes someone a science person?'
> Cordelia: 'Just maybe if your family's very involved with science, like say, if your dad was a doctor or something.' (Interview, June 2014)

Sharifa, on the other hand, related her identification with science directly to the fact that many members of her family were involved in it. She considered herself to be a 'science person' because, in her words, 'my family, like my mum, she likes science and I like science as well and all my brothers like science and my cousins all did science degrees and stuff'. For Sharifa, identifying and aspiring to a science-related job was a thinkable option, because this trajectory was normalised within her family. Accordingly, I would argue that Sharifa's family had a science-oriented family habitus (Archer et al., 2012b).

Problematising science capital

The girls in this study had relatively little overall science capital; only a few mentioned knowing people who did anything science-related and most did little or no science outside school, such as talking to parents about science, visiting science-related places and consuming science-related media. Further, I suggest that even the experiences and resources that appeared to have the capacity to generate science capital, or that could potentially 'count' as science capital if researched through a survey questionnaire (Archer et al., 2015), did not always have exchange value in practice. These findings complicate the notion of science capital and highlight the difficulties regarding girls from disadvantaged backgrounds gaining and deploying resources that would support their engagement with science.

Past family visits to places like science museums appeared to have limited scope to generate science capital. This was, firstly, due to the challenges parents spoke about encountering during their visits, which resonated with the findings of previous studies that highlighted the issues of inclusivity in relation to informal science learning environments (A.N.D., 2014; Davies, 2014; Dawson, 2014b). Parents like Samira's mum, who had previously visited a science museum with her daughters, complained about the accessibility issues, which made it difficult for her to navigate the visit.

> Samira's mum: 'I like [a science museum], but I do not understand the written description in English. I need to read to understand, so I need a translator to read it. I would like to learn English, but I can't with my situation now. It would be good to have a translator right next to the collection or an electronic translation device. Like in the Internet, it is an easy idea to be applied.' (Interview, December 2014)

Linguistic barriers, such as not being able to understand the science museum labels in English, largely appeared to have prevented Samira's mum from engaging with science in the museum. Consequently, I suggest that this probably made it more difficult for her to participate in science-related conversation with her daughters. This was a missed opportunity for Samira's mum, who spoke about a keen interest in science, which she exemplified by watching science programmes on Arabic television and frequently discussing the topics with her children afterwards. Some of the challenges in terms of inclusivity that Samira's mum spoke about prior to the project family visit were later observed during the visits of her and other families (see Chapter 7).

Visiting museums and cultural institutions has been generally regarded as generating a form of educational cultural capital (Bourdieu, 1984; Dumais, 2002). Yet, it appeared that for the parents who had little science capital and who were not interested in science, the visits to science museums were more focused on leisure, rather than on engaging with the subject. Larisa's mum, for instance, mentioned that they regularly visited a local science museum, which was conveniently located very close to their home. She considered it to be a particularly suitable destination for when they had out-of-town visitors with children. However, Larisa's mum admitted that science was something she was not really interested in and said that they never talked about science or did any science-related activities as a family ('I don't mind if I just need to go to the museum and you know, look around, but to be honest, I'm not into science, never been into science.'). I would contend that simply going to the science museum may not have necessarily extended to engagement with science. For Jasmine, similarly, who had been to the science museum several times before participating in the study, these visits were mostly about doing something fun and 'playing games'. It is difficult to say what the science capital building capacity of these experiences was, but I suggest that given the explicit disinterest in science (as stated by Larisa's mum and Jasmine), this capacity may have been quite limited.

The girls' participation in science-related activities at home was also relatively rare. The data suggest that simply possessing something like a science kit did not mean that the girls were engaging with it. While some of them mentioned that parents and relatives bought them science kits, this did not necessarily translate into their using them. Hence, the potential for capital generation may again have been limited. While possessing educational resources would be seen as capital in itself, according to Bourdieu (1986), the girls' resistance to participating in these practices may have limited the extent to which the capital was ultimately generated. For instance, Caitlin's mum mentioned that Caitlin's dad had bought a number of science kits (such as crystal growing kits) for their daughters, but the girl could not recall ever using them. These findings complicate the notion of science capital, in that it is not sufficient to consider what people have access to (possess or experience), for it is important to examine in more depth how resources and experiences are used in the process of gaining capital.

There were several resources that I coded as science capital, such as parental skills and qualifications, but these appeared to be under-recognised and under-realised by their parents. For instance, Dorota's mum mentioned taking a 'gardening and agriculture' university course in her home country, which she did not see as having much to do with science. In her words, there was 'no science in there […] you know, we had something which we had to learn about chemicals and stuff like this, but I don't know if it counts as science'. Caitlin's mum, further, mentioned working with chemicals and hazardous substances in her role as a school cleaning manager, which she did not consider to involve any science. I argue that by not recognising the resources they possessed, it was unlikely that these resources were actualised and thus, only had limited exchange value (Skeggs, 2004c).

The value of parents' science capital was also constrained by the extent to which the girls recognised and deployed it. Rifat mentioned that her dad worked as an engineering technician, which I coded as a form of science capital, but as she said, she had never talked to him about his job. She admitted that she could not 'pick up the courage' to ask her parents about science and added that because they were 'not from here [the UK]', they were not able to help her with education much in any case. Despite possessing science capital within the family, this capital was not leveraged. And as Lareau & Horvat (1999) have argued, there is 'an important difference between the possession and activation of capital or resources' (p. 38). Without activation, capital only has limited value in reaping advantages and supporting engagement with science.

The findings I discussed in this subsection indicate that there is an ethnic aspect to science capital (different from the so-called 'ethnic capital' that I discuss below). Parents who were not fluent in English, who gained qualification outside the UK and who were less familiar with the UK education system, appeared to have encountered difficulties in enabling science capital building opportunities for their daughters. The reason I argue that science capital was ethnicised is because migration to the UK appeared to have complicated the extent to which the girls could leverage their already limited science capital available within their families. Migration to the UK would, I presume, have different implications for a family who moved from an English-speaking country and who would thus not have encountered the level of language barriers reported by the parents participating in this study.

Intragenerational science capital

The education literature has predominantly focused on the role of the immediate family (parents) in supporting children's education and shaping their dispositions. The data from this study suggest that the extended family and wider community also played an important role in shaping the girls' preliminary engagement with science. As many of the parents faced structural limitations and were disadvantaged in the UK following their migration from abroad, siblings, distant family members and ethnic community members valuably contributed the sources of support that the girls were able to access and draw upon. Several girls spoke about the resources they had available from other family members. The South Asian Muslim girls, in particular, emphasised the importance of their siblings and other younger relatives in supporting their education and science.

> Layla: 'I talk to my big sister [about science], because she had GCSEs a while ago so she was revising science and things. She's really good at science, she's 'oh, what are you learning?'. She'll sit down and explain things to me. I think my big sister helps me more than my mum and dad. Because I think she is used to it more than mum and dad, because she's been doing it like me, every single day. … You are also more comfortable talking about science or whatever to someone like my big sister, who

> are near your age, than to my mum and dad, or a more older person.' (Focus group, June 2014)

As noted by one of the participating teachers, 'it's often big brothers and sisters, rather than parents [that come into school], because they can speak the language'. In some families, older siblings appeared to have taken up the role of parents, which other studies have found to be common among British Asian families. Previous research in British Pakistani communities, for instance, has found that 'children are active participants in generating social capital for themselves, their parents and siblings' (Shah et al., 2010, p. 1118). Crozier & Davies (2006) have elicited that, in Bangladeshi and Pakistani communities in the UK, support for children's education lies not only in the hands of parents but also with the extended family and community network.

In one case, even a younger relative was seen a source of support. Rifat mentioned that to find out more about what she needed to become a games designer, she would turn to her 9-year-old cousin, who was really good with computers and computer games. While she admitted that 'obviously he's not like a professional or whatever', his skills seemed to have legitimised him as a source of capital that Rifat would leverage ('he wants to create his own computer at the age of nine and I'm just like, that's absolutely pretty amazing'). While valuable, however, I speculate that this form of capital might have only limited value in supporting Rifat's quest of pursuing her aspiration to become a games designer.

The role of ethnic capital

I began to argue above that ethnicity (through the values permeating the girls' ethnic communities) played an important role in shaping what the girls considered as desirable career trajectories for them and it positively influenced their science-related aspirations. I now explore the influence of the girls' ethnic background through the notion of ethnic capital (Modood, 2004; Zhou, 2005), which I see as inclusive of broader social and cultural ethnicity-specific resources.

The girls spoke about ethnic ties in the form of relatives who had science-related jobs, many of whom lived outside the UK. Rifat mentioned relatives working as doctors in Bangladesh, Sharifa had family members in science-related jobs in Pakistan, Layla had an uncle in engineering in Pakistan and Samira had family involved in medicine and engineering in Iraq. These relatives appeared to have served primarily in shaping the girls' habitus, through making careers like medicine thinkable for them and through being positive role models (Crozier & Davies, 2006). Yet, as Samira remarked, these extended family members played a rather marginal role in the girls' lives and I thus speculate, offered little practical support.

> SG: 'Do you ever speak to these relatives [in Iraq] about science or medicine, are you in touch at all?'
> Samira: 'We're in touch with them, we go on holidays sometimes, but mostly it's more about like general gossip and how the family is and like, who's getting married and things like that, rather than like their jobs and things like that'.
> (Interview, March 2015)

I would contend that this transnational capital was underused and of little value for Samira who lived in the UK. As I noted above, capital is only valuable when it is 'mobilisable' (Anthias, 2007). The social and geographical distance from the possible source of capital appeared to have made it difficult for these relatives to play a bigger role. As Gilmartin et al. (2006) have argued, 'it is not enough to have a family member who does science-related work – more important is the extent and nature of interaction with this family member' (p. 185).

The local ethnic community in the UK appeared to have, in some cases, served as a source of information for the parents (and, consequently, their daughters). Samira's mum, for instance, spoke about strongly relying on members of Iraqi community in her local area to provide her with information regarding education, which she felt she was unable to obtain from Samira's school, 'I ask my friends whose kids are at the university and had the same experience before and I learn from them'. Such 'hot' or grapevine knowledge (Ball & Vincent, 1998), i.e., word of mouth rather than official institutional knowledge, however, seemed to have limited capacity. Samira's mum stated that she wished that more information and support was available from her children's school. She struggled accessing the available resources due to her poor English skills. Relying on her co-ethnic network of fellow migrants, as others have noted, appears to have limited the 'horizons of possibilities' available to her and her family (Crozier & Davies, 2006, p. 688).

The analysis of science capital indicates that across the cohort, the resources to support the girls' preliminary engagement with science were limited and where available, they were not necessarily recognised or realised. Despite ethnicity positively shaping the girls' aspirations towards science, they often lacked symbolic capital to support their engagement with science, as it has been noted in previous work.

> Although some working-class minority ethnic families were able to draw on cultural discourses (of science as a desirable/appropriate career aspiration) that encouraged and supported science aspirations among children, these aspirations were still circumscribed to some extent by a lack of wider capital. (Archer et al., 2012b, p. 904)

The issue of high aspirations, yet low level of dominantly valued capital to support them, has previously been discussed through the notion of aspiration-achievement paradox (DeWitt, Archer, et al., 2011). That is, despite high aspirations to pursue careers like medicine, some students were found to struggle with the conditions needed to achieve the academic success that would have enabled such trajectories. Concerns along similar lines were also raised by Mr Bramley, who reflected on the fact that many South Asian girls at their school aspired to pursuing A level science and demanding medical careers despite having relatively low grades.

> Mr Bramley: 'I mean, that surprised me at the year nine parents evening, the ability group I've got, I would never expect any of them to want to go on and do science at A Level but there's all of them saying, oh, I'd like to be a vet or I'd like to be a doctor and you just think, so this is not what I'm used to sort of thing, because most people of that ability want to kick science into touch as soon as they possibly could.' (Interview, March 2015)

What this suggests is that ethnic capital might be able to support the habitus in terms of normalising science and science-related trajectories, yet may run into difficulties when the available resources cannot support the chosen path. This could manifest, as Rifat's case above suggests, in experiencing doubt regarding own competences. The capital available may have been in conflict with desired trajectories also for Samira, who appeared to have not fully internalised her mum's attitudes and values as achievable for her despite being a top student in her school.

> Samira: '[Mum] thinks I'm going to be a scientist when I grow up. She wants me to take triple science and she wants me to take it for my A levels, chemistry, biology, maths, higher maths, geography and that's kind of hard and on top of that, she wants me to take German A level as well, because that's like extra, to get to do that.'
> SG: 'What do you think about that?'
> Samira: 'I don't know. It's a good choice but it's going to be really hard.'
> SG: 'Yeah, you think it will be really hard?'
> Samira: 'She wants me to get into Oxford but I don't think so.' (Interview, March 2015)

This excerpt illustrates Samira's mum high expectations for her daughter, which Samira appeared to have struggled to see as possible for her. The girls may have accepted what Bourdieu (1977a) has referred to as 'objective probabilities' of their future success, which could result in their self-elimination from the field. Parents' difficulties in supporting their children in education were also mentioned more directly. Alimah's dad, for instance, said that he 'would like to be encouraging' (he had aspirations for his children to go into either medicine or engineering), but he also admitted that he rarely helped them with their schoolwork. Instead, he offered them financial incentives to study harder: 'I told my son, if you get a high score in maths and science, I will give you £100 every year. He said yes.' I suggest that such an approach might present a weak alternative to active parental involvement in children's education. Overall, the findings from this study would appear to indicate that while most parents held high aspirations for their daughters, the girls had limited resources available to assist the aspirations. This raises concerns about how their high aspirations might play out in the future.

4.6 Usefulness of the theory of social reproduction for understanding preliminary engagement with science

In this section, I reflect on the usefulness of Bourdieu's theory for examining preliminary engagement with science. I pointed out in Chapter 2 that his theoretical framework has been usefully drawn upon in a number of previous education studies, including on science-related aspirations and engagement with science. I agree with Skeggs (2004b) that Bourdieu's theory has an 'explanatory power not offered elsewhere' (p. 21, emphasis removed) for examining the reproduction of social inequalities. Applying Bourdieusian analysis, in combination with the work that has extended his theory to include the influence of ethnic and migration background, has enabled me to examine what the girls brought with them to the study and how their experience at home and school as well as available resources, contributed to their preliminary engagement with science.

Bourdieu's theory provided a useful focus for discussing the role of social class through the concepts of habitus, capital and field. The theory of social reproduction helped to explain why some working class families encouraged educational trajectories that tend to be typical and 'normal' for people like them. In this study, the socioeconomic background appeared to be powerfully mediated by ethnicity and migration history, which has shifted the trajectories from being reproductive (what Bourdieu would have expected to be the most common trajectory), to being responsive and aspirational. The notion of ethnic capital, i.e., resources related to one's ethnic background that can mediate classed trajectories, was a useful addition to Bourdieu's theory in this chapter for explaining the patterns of engagement with science for many ethnic minority girls in the cohort.

This theory was less helpful for unpacking why some students appeared to go 'against the grain'. Dorota, for instance, had a strong preliminary engagement with science, yet very little capital available within her family. Her mum admitted to not particularly liking science and Dorota did not see her parents as at all interested in it ('science isn't very important to him [her dad] or to my mum'). Dorota said that when she needed information about science, she turned to the Internet. Her mum admitted that she was often not able to help Dorota with her homework ('I think she knows it [science] better than me.'). Dorota, in this sense, appeared to be proactively choosing science despite the limited science resources available to her within the family or any particular encouragement regarding the subject, as there was for the girls from South Asian backgrounds. Bourdieu has admitted that 'no two individual histories are identical so no two individual habituses are identical' (Bourdieu, 1993, p. 46), yet presupposed that similar experiences would lead to similar habituses. Hence, his work has little explanatory power for why two very similar individual histories may produce two very different habituses (such as in terms of aspirations and what is thinkable/desirable). Nash (1990) has previously pointed out that the socialisation theory developed by Bourdieu was simply not designed to explain individual actions and explanations about these would have to come from other theoretical lenses.

Finally, as I argued in Chapter 2, Bourdieu's theory also provides limited theoretical tools for examining the role of gender, which plays an important role in engagement with science, as evident from participation figures I presented in Chapter 1. In order to be able to interpret the engagement patterns further and add the perspectives according to gender theory, I discuss the data about the girls' preliminary engagement with science through a gender lens in Chapter 6.

4.7 Summary

In this chapter, I have examined the girls' preliminary engagement with science through a Bourdieusian analytical lens. I mapped out the girls' preliminary engagement with science in five categories: strong, partial-problematic, partial-pragmatic, partial selected preliminary engagement with science and dis-identification with science. I then discussed how the girls' dispositions were shaped by the interplay of habitus and the fields of family and school as well as by the capital that they had available and whether or not, they were able to mobilise it. I argued that despite seemingly having working class backgrounds, the majority of parents had attitudes to education and science that were more aligned with the typically middle class values, in that they expressed high academic and professional expectations for their children. Ethnicity and migration history played an important role in shaping a habitus that was responsive to the current disadvantaged situation, rather than it being reproductive in a Bourdieusian sense. Science was considered by many of the girls and their parents to be a particularly valuable and desirable career trajectory for achieving social mobility. The girls, however, mostly had low levels of science capital, which influenced their identification with the subject and I suggested this might constrain their longer-term engagement with it. In addition, the already limited amount of capital they possessed was not always actualised and hence, had a limited exchange value.

Chapter 5: Girls' engagement with science during science lessons and class visits to the science museums

5.1 Introduction

In the previous chapter, I discussed how the girls' past and present experiences at home and at school as well as the resources they possessed and realised, shaped their preliminary engagement with science. I now move to engagement in practice that I observed during science lessons and class visits to the science museums. I discuss these together, because the analysis of data suggested that there was little change in the field as the class moved from the classroom to the science museum. Put another way, the change in physical setting appeared to have made little difference in terms of the relations between teachers and students as well as the rules and expectations that structured the activities they participated in. I begin to address the second research question: **How do interactions of gender, social class and ethnicity shape girls' engagement with science within lessons, class visits and family visits to science museums?** I draw primarily on observation notes from science lessons and class visits, which I triangulate with the data from interviews and focus groups I carried out with the students and their science teachers after the visits. Taking a Bourdieusian theoretical approach, I examine what rules and norms existed within the two physical settings and in what ways the dis/alignment between capital, habitus and field contributed to the production of the girls' engagement with science.

I begin by examining in what ways the field of school science constrained the girls' opportunities for engagement with science, through a discussion of what was expected and valued during the practices the girls encountered. I then look at what contributed to producing occasional moments of engagement and discuss how capital, habitus and field contributed to shaping these. In particular, I focus on one activity during the class visit to the science museum that enabled some of the girls to engage in ways that appeared not to be possible in the classroom. I conclude the chapter by reflecting on the usefulness of the Bourdieusian theoretical framework for examining the influences on the girls' engagement with science in practice.

5.2 Change of physical setting – change of field?

When I initially designed this study, I planned to examine how the girls engaged with science within three activities: science lessons, class visits and family visits. I anticipated that the class visits to the science museums would provide different opportunities for the girls to engage with science than their lessons. Based on the data analysis I carried out, however, I argue that the change of physical setting did little to disrupt the normative ways of doing science I had observed during the science lessons. Put another way, there was very little shift in the field. Science lessons and class visits to the science museums were largely part of the same field, or 'sector' of the world (Bourdieu, 1998). Many of the expectations and norms of the classroom were also present during the visit. These findings resonate with Bourdieu's thesis that field is not about a physical setting, but rather about a set of relations between the participants, norms, expectations, value and recognition, which tend to be more difficult to change (Bourdieu & Wacquant, 1992). Moving social relations or 'field of struggles' (Bourdieu, 1983, p. 312) to a new physical setting does not, therefore, necessarily constitute change.

5.3 Tensions between habitus, capital and field: Constraining engagement with science in practice

Norms and expectations within the field of school science

Most of the science lessons and the class visits I observed were dominated by a handful of students. The majority of the girls I focused on for this study rarely engaged in visible ways and when they did, their participation was not always received positively by those around them. I suggest that the norms and expectations of the field of school science were somewhat restrictive, enabling some students to engage with it better than others. I was particularly interested in who participated during the lessons, what participation looked like and whether there were any tensions that constrained the girls' engagement with science.

The science lessons I observed resonated with typical or mainstream science lessons discussed in the literature and what Carlone (2004) has called 'prototypical science education'. My observation notes indicate that the science lessons demanded that the students complied with instructions, behaved well and used correct vocabulary when speaking out (see also Chapter 4 for how the girls spoke about 'science people' in their classes). Other studies have reported that such 'normative practices' of the science classrooms (Carlone et al., 2014) tend to, unsurprisingly, privilege students who are well-behaved, comply with instructions and who are able to contribute to discussions by offering school-sanctioned scientific knowledge. This resonates with the findings of this study.

Observation notes reveal that when the students' behaviour did not meet the science class expectations, this in some cases resulted in tension. An instance from Mr Bramley's practical science lesson provides an illustrative example of the sort of tension between students' behaviour and the norms and expectations of school science. During this particular lesson, the students participated in a practical activity that involved dropping coloured liquid from various heights, in order to measure the effect this had on the size of the mark when the drop hit the paper. The activity was performed in groups of three to five students. After some time, the class began to get louder, albeit with many of the girls still appearing to be doing their practical work. The increasing noise elicited the following scenario.

> Mr Bramley seems concerned about students' work. 'Can I stop you?' At first, the girls keep on chatting, but they slowly calm down.
> Mr Bramley 'Messing around is not a scientific skill' […] Mr Bramley continues with his telling off, says how some students were good while others not so much; he will not point fingers but 'a 3-year-old would do a similar job'.
> He says some girls have a 'scientific mind', he knows some do, but they have 'reverted to childhood, no, babyhood!'
> The class is very quiet and all of the girls are looking down avoiding making eye contact. (Observations, LH science lesson, June 2015)

While I regularly observed teachers telling students off for chatting, not listening or doing things unrelated to the science lesson, this example stood out, because Mr Bramley seemed to make an explicit link between students' behaviour and (not) being scientific. Mr Bramley compared the students' behaviour to young children and babies, thus infantilising it. I suggest that students who did not behave appropriately were labelled by their teacher as 'not ready' for school science (Nash, 1990). While Mr Bramley's commentary was in this case not directed at any of the girls in particular, I would argue that it powerfully conveyed the message about whom science was for. Following Bourdieusian theory, students whose behaviour is attributed a negative status and stigmatised by those in the position of power (e.g., science teachers), might as a result withdraw from the field (Bourdieu, 1974; Nash, 1990).

Rejected engagement with science

The tension between the girls' habitus, capital and the field of school science also contributed to a disruption of the girls' bids to engage with science. By bids to engage, I refer to the instances when girls attempted to engage with science during their lessons and the class visits to the science museums. When they tried to do so in ways that were not considered appropriate within the science lesson, these were explicitly rejected by their teachers and/or their peers. Further to the above instance of tensions related to behaviour, my data indicates that the girls' attempts to engage with science were problematic and denied also in other ways. Hayley, for instance, who otherwise articulated an interest in science and an aspiration to become a research scientist, appeared to be largely disengaged in the classroom. The notes on her science lesson participation mostly consisted of her chatting, drawing pictures and avoiding tasks requested by her teachers. Yet, when she occasionally sought to participate, her attempts appeared to be in conflict with her teachers' expectations. During one lesson, Hayley insisted on challenging Mr Bramley's explanation, specifically his instruction that they should disregard the experimental measures, if these did not fit with the expected results in their books.

> Mr Bramley asks [the class] what to do with anomalies. Hayley [previously not paying attention to the activity] now starts participating in the discussion 'Do it again?' When Mr Bramley says they probably do not have enough time for this and suggests they should just omit them, Hayley protests that this is sort of 'cheating'. She is confident and assertive. Mr Bramley ignores her and tells students to get on with the work. As the discussion about anomalies continues, Hayley starts cutting out some shapes out of paper. She is no longer engaging with the discussion. (Observations, LH science lesson, June 2015)

I suggest that Mr Bramley rejected Hayley's 'bid for engagement' with science, because it appeared to be in tension with normative ways that he expected his students to observe, i.e., to follow his instructions. In order to engage successfully with science during the science lessons, they were expected to participate in line with expectations. As J. B. Thompson (1991) has put it, 'if one wishes to produce discourse successfully within a particular field, one must observe the forms and formalities of that field' (p. 20). To observe these 'forms and formalities' of a particular field, Bourdieu would have argued that a person needs to have a 'feel for the game' (Bourdieu, 1990a). This means that students would need to be aware of and embody appropriate ways of behaving in the science classroom. When a student's habitus is in poor alignment with a field, meaning that their ways of talking, behaving, participating are not deemed appropriate, the resulting tensions may compromise the production of student engagement with science. In the words of Reay (2008), 'when habitus and field do not accord there are inevitable conflicts and disjunctures' (p. 93).

Consequently, I would contend that students are held accountable to 'normative practices' of the classroom (Carlone et al., 2014), which dictate the opportunities they have for engaging with science. Previous studies have argued that the 'pedagogy of control' that is often associated with science education permeates science classrooms from early stages of education onwards (Varelas et al., 2011). The associated rules and expectations play an important role in student engagement with science. Despite interest in and aspirations towards science, students who do not have a 'feel for the game' and those students who do not observe the norms and expectations of the classroom, might struggle to engage with science in the science lessons in ways that are valued, celebrated and supported by the field (Calabrese Barton et al., 2012; Carlone, 2003; Varelas et al., 2011).

The data suggest that engagement with science was further constrained by the ways the girls talked science. I interpreted the girls' ways of talking science as an interplay between capital and habitus (i.e., including linguistic and science-related capital as well as knowing how/when to use it) (Bourdieu, 1991). Below, I discuss two instances when the girls' way of talking was met by rejection, one from the science classroom and one from the class visit to the science museum. The examples highlight that the enforcement of the 'rules' of school science was not only carried out by the teachers, but also by the students themselves.

Jasmine was one of the girls who I categorised as dis-identifying with science. She did not consider herself to be a 'science person' and did not aspire to doing anything science-related in the future. Despite mostly disengaging during her the science lessons, she occasionally made an attempt to participate, such as by volunteering to answer the teachers' questions. One such instance was particularly exemplary of the tension arising from Jasmine not speaking science 'properly', being how I interpreted Mr Cohen's comment.

> Mr Cohen mentions that they might see lightning later today as there will be storms, Jasmine loudly says 'yessss!' Jasmine volunteers to answer a question, says about how 'lightning goes up'.
> She explains this is because 'the ground shakes sometimes'.
> Mr Cohen: 'what's that, a start of a song?'
> [Jasmine does not attempt to participate in classroom discussions for the rest of the lesson.] (Observations, NS science lesson, July 2015)

Mr Cohen appeared to have rejected Jasmine for not speaking science in an 'appropriate' way, but instead like 'a start of a song'. I considered his association of Jasmine's response with popular culture as dismissive, devaluing of her attempt to contribute to the discussion. Popular culture has, moreover, dominantly been framed as antagonistic to and in tension with schooling (Francis et al., 2010; Walkerdine, 1998b). The tension between Jasmine's way of talking and the expectation of her teacher was not conducive with producing further engagement with science, which was evident from the absence of any note indicating Jasmine's participation for the rest of the lesson. The field of school science made engagement with science difficult for the girls who did not play by the right 'rules'. Bourdieu (1984) has highlighted the powerful role of status attribution, both negative and positive, which he considered to be 'the best-hidden effect of the education system' (p. 23). Some behaviours (and resources, ways of talking) are valued and celebrated within the field, while others are denied. Teacher's recognition of behaviours as inappropriate within the science classroom could, in line with Bourdieu (1984), contribute to 'condemning valueless dispositions to extinction' (p. 85) and result in students disengaging or self-excluding themselves from the field.

The field of school science was not only structured by teachers' expectations, but also by students' perceptions of what was suitable and acceptable. This was evident in students denying their peers' participation if they considered it to be poorly fitting with the normative practices of science education. An example from the Northfields School class visit to the science museum is particularly illustrative. During the visit, Aliyah (who spoke about having some interest in science, but rarely visibly engaged during the science lessons) was in a group with two male classmates. The following observation notes illustrate how her attempt to participate was shut down by the boys, who laughed at her pronunciation and rejected her attempt to participate in the presentation.

> Aliyah starts talking about the Apollo but the boys laugh at her pronunciation of the name so she stops. […]
> Aliyah starts trying to do her presentation again 'OK this is the Apollo lunar…' and her male classmate shouts 'CUT!' over the top.
> [The boy and Aliyah then argue about who should go first, until they run out of time to finish the filming and have to join the rest of the class.] (Observations, NS class visit, November 2014)

By laughing at Aliyah’s pronunciation and interrupting her presentation, I believe that the boys compromised Aliyah’s opportunities for engagement with science. This example speaks to previous findings that students were not held accountable only to their teachers, but also to other participants within a particular social context (Cobb, Gresalfi, & Hodge, 2009). As Mehan (1979) has argued, students ‘must learn the appropriate form in which to cast their academic knowledge. […] They must know with whom, when, and where they can speak and act, and they must provide the speech and behaviour that are appropriate for a given classroom situation’ (p. 133).

As a number of other studies have previously argued, talking science plays an important role in students’ engagement with it (Brown, 2006; Lemke, 1990; Roth, 2005; Wellington & Osborne, 2001). Lemke (1990), for instance, has pointed out that ‘doing science is always guided and informed by talking science’ (p. xi). By being silenced or not allowed to speak, the girls’ opportunities to engage with science were compromised. Such instances, furthermore, had a power to contribute to a reproduction of the field where only some students (those able to speak science ‘properly’) were able to participate competently. The girls’ involvement in science discussions and presentations ('claiming voice', see Carlone et al., 2014), I suggest, played an important role regarding how they were recognised by their teachers and their peers. This, consequently, had implications for their dispositions in relation to science (see Chapter 4), as others have found (e.g., Brown, Reveles, & Kelly, 2005).

Withdrawing from the field

When the girls’ behaviours and ways of talking science were in tension with the field of school science, this in some cases resulted in their withdrawal from the field, as I illustrated with the data examples above. Further, some of the girls appeared to have withdrawn from the field, because engagement with science (within that particular field, at least) was not desirable to them in the first place. Eight of the girls in the study were consistently observed disengaging during science lessons and class visits to the science museums. This was evident in there being very few instances I coded as engagement with science and in the presence of those for explicit disengagement, which included hiding from teachers, chatting and participating in activities unrelated to science. For four of the girls, Caitlin, Jasmine, Alimah and Larisa, who I categorised as dis-identifying with science, the subject in general appeared to offer little appeal. In Bourdieu's terms, the 'game' of science may have not been worth 'playing' for them. This seems to be because they did not see it thinkable or desirable to continue with science beyond compulsory education (see Chapter 4).

Particularly interesting was the case of the two girls who withdrew from engaging with science during science lessons, but who appeared to be more engaged with it outside the classroom. I argue that this was at least in part a consequence of a tension between their habitus and capital and the field they encountered during their science lessons. The girls' accounts of participation in science-related activities outside the classroom, on the other hand, suggested that it may have been school science, in particular, that was problematic and not science in general. Layla and Hayley provided an illustrative example of this situation. These two girls rarely engaged with science during the lessons; they mostly chatted to each other and sat as far away from the teacher's desk as possible. As Lemke (1990) has warned, students' active disengagement during science lessons should not simply be dismissed as inappropriate and immature, as their disengagement may reflect tensions with the existing rules and expectations, as demonstrated with Hayley's case. It is important to acknowledge that 'antagonism to the rules reflects the differences between our interests as we see them and the interests of those who have the power to decide what the "official" rules will be' (Lemke, 1990, p. 57).

The data suggest that Layla and Hayley were far more engaged with science outside school. This was particularly evident in their participation in preparing the activities and exhibits for the end-of-year school's science fair, whilst also being so in their account of reading about science in their spare time. At the time of the study, they were working for several months on making a series of interactive 'organ system' exhibits, which they planned to use for educating other students and adult visitors about human anatomy and physiology. The girls had negotiated with their teachers that they could skip one science lesson every week in order to work on their project. Hayley mentioned that she was particularly looking forward to her mum and grandma coming who she hoped would be very proud of her work. I interpreted these data as showing a stark contrast between engagement with science in the classroom, whilst being active and keen regarding it outside the classroom.

It was evident that the social context mattered for engagement with science. The role of the context for shaping student engagement has been widely established in the literature (F. S. Azevedo, 2011; Lawson & Lawson, 2013). A particular field may open up or close down opportunities to produce engagement. I suggest that Hayley and Layla were 'unmoved by the game' of school science (Bourdieu & Wacquant, 1992, p. 116), yet 'moved' by the science activities that were available to them outside the classroom. In Bourdieu's terms, opportunities available to them outside school appeared to enable for them better alignment of their habitus and capital, hence producing stronger engagement with science. This speaks to the argument that non-school contexts might have the potential to provide different opportunities for young people to engage with science, yet as I noted above, simply changing a physical setting might not in itself be able to provide better opportunities for such engagement.

5.4 Degrees of alignment between habitus, capital and field: Producing engagement with science in practice

Moments of engagement with science

Engagement with science appeared to be improved when there was a greater alignment between the girls' habitus, capital and field. Two girls stood out regarding this during the science lessons, namely, Dorota and Samira. In the previous chapter, I argued that these two girls had a strong preliminary engagement with science and suggested that this was in part shaped by their positive experiences at school and the recognition they received from their teachers. In this subsection, I examine the data about their engagement with science in practice.

Engagement with science was produced when the girls' ways of behaving and participating aligned with expectations. Samira, for instance, consistently participated in science lessons in ways that were expected by the school and celebrated by her teachers. She was on-task, paid attention and frequently put her hand up when she wanted to contribute to the discussion. The following excerpts from the observation notes from these lessons illustrate Samira's active participation, which I interpreted as strong engagement with science and positive recognition from her teacher, Mr Cohen (see also Chapters 4 and 6 for how teachers articulated who they considered to be 'good' science students).

> The usual few students put their hands up – Samira, four boys. (Observations, NS science lesson, November 2014)
>
> Mr Cohen counts again 1, 2, 3, 4 [he does this to get the class to listen to him] … He wants to show them [students] an example of good work and grabs Samira's notebook on the way to the projector so that everyone can see. 'See, Samira has smartly used her previous work…' He lets Samira explain the rest. (Observations, NS science lesson, November 2014)

Samira participated in ways that were celebrated by the field of school science. She appeared to have a 'feel for the game' (Bourdieu, 1990a). Both Samira and Dorota also appeared to possess and were able to draw on dominantly valued capital. During the science lessons, this was mostly evident in the form of scientific literacy, which aided them in being able to contribute to classroom discussions. I see the teachers' positive recognition of these girls' behaviour as an instance of the interplay of capital and habitus being valued within the field. Drawing on the work of Dumais (2002), I suggest that Samira's behaviour served as a form of 'signal' for her teacher to promote her and, which gave her positive affirmation of her classroom participation.

On the other hand, the girls who were quiet and who did not participate extensively in classroom activities were not recognised as 'scientific' to the same extent. Five other girls (Amna, Asqa, Sharifa, Niya and Rifat) appeared to be relatively engaged during their lessons, which was evident from their performing tasks as per teachers' instructions. However, these girls rarely showed the sort of agency and initiation that Samira and Dorota did. Their habitus appeared to be to some extent aligned with the norms and expectations of the science class, in that they did the required work. Yet, it appeared to not be adequate to 'play by the rules' in terms of good behaviour, for it seemed to also be necessary to ensure that engagement was visible. Otherwise, the girls' risked not getting the recognition from the teachers. I further discuss these data through a gender lens in Chapter 6 in terms of restrained femininity risking invisibility.

During the science lessons I observed, I did not record any instances where the girls leveraged capital other than scientific literacy. Science lessons tended to follow pre-designed schemes of work and teachers' questions mostly related to eliciting curriculum-related knowledge. It has been argued in the literature that traditional science lessons, indeed, rarely offer opportunities for young people to contribute (and get valued) for bringing in and sharing the knowledge and experience they have from outside school (Calabrese Barton, Tan, & Rivet, 2008). In Bourdieu's terms, the field that these girls encountered appeared to offer limited opportunities for the girls' to draw on their other resources (i.e., beyond curriculum-related scientific literacy) and have these recognised and valued.

Shift in the field during class visits to the science museums

As I argued above, class visits to the science museums largely maintained the social relations, values, norms and opportunities as in the classroom. For Samira and Dorota, the strong engagement with science that I observed in the classroom appeared to largely translate into the setting of a science museum. In similar ways as at school, the girls consistently participated in science-related conversations with their teachers and remained on-task for most of the day. Further, the respective science teachers spoke highly about their engagement during the visit (particularly about Dorota; I discuss a slightly more problematic case of Samira's involvement during the visit below). Mr Bramley described Dorota as 'thriving' during the visit and recalled that she was 'really asking questions'. On the other hand, the girls who were largely absent from the observation notes during the science lessons in terms of engagement with science were also rarely observed engaging with science during the visit or their attempts to engage were problematic, as I demonstrated above happened in Aliyah's case.

One activity, however, stood out. The visit enabled some additional opportunities for engagement with science, which I now discuss in terms of the shift of the field. Albeit brief, these instances of opportunities indicated what was possible when the 'rules of the game' shifted, in such a way as to value a broader range of resources and recognise a broader range of behaviours as expected and desirable. This shift in the field, as a consequence, contributed positively to producing engagement with science. Gresalfi, Martin, Hand, & Greeno (2009) have previously argued that engagement depends on and is shaped by 'an interaction between the opportunities that a student has to participate competently and the ways that individual takes up those opportunities' (p. 50). Having an opportunity to participate competently in the activities during the visits to the science museums enabled a few of the girls to engage with science in ways I did not observe at school.

While school science seemed to mostly value capital in the form of scientific literacy, the girls had opportunities to leverage a wider range of resources during a particular activity that took place during their class visit to the science museum. This was the filming of the presentations that they had previously prepared in their pre-visit science lessons. To present the museum objects the girls had been allocated, they were encouraged to draw on a broad range of skills, such as singing, dancing and the knowledge of popular culture (see Appendix 2 for the object presentation plan template). A few of the groups, resultantly, prepared presentations involving pop songs, acting and dance choreography. In this way, the girls were able to use resources to engage with science that would most likely be unsanctioned during the science lessons (Calabrese Barton et al., 2008). Drawing on popular culture tends to have little value at school and has been framed as anti-school due to its association with working class pursuits and aspirations (Bourdieu, 1984; Tan & Calabrese

Barton, 2008). The following example from a group of girls from the Northfields School (Alimah and two girls who were not included in the study) illustrates what these presentations were like.

> Alimah, girl1 and girl2 stand in front of their object. They are right on the busy path where a lot of people are passing. Mr Cohen tells them that they have to be very loud. Girl1 has created a pop song with a dance about the Apollo 10 [she tells girl2 and Alimah when to start and is leading the dance routine]:
>
> 'Apollo 10
> That's the name
> It went up to space and down again
> Up – and down again,
> Down again, down again…'
>
> [Mentioning some numbers and facts about the museum object next ...]
>
> They sing and dance to a pop tune. The gallery is very loud and Mr Cohen tells the girls they will have to do the filming again. He suggests going to the side of the object, as there will be fewer people passing them there.
> Sharifa films again, while girl1 leads the performance: 'Ready, now?'
>
> 'Apollo 10
> That's the name
> It went up to space and down again
> Up and down, down again
> That's pre …
> It's fastest and it …
> It just about fits in this room,
> Yeah? No way!'
>
> Alimah and girl2 follow the dancing and singing with girl1, who is clearly the leader. Mr Cohen says they did this in class yesterday. [He seems proud and amused]. Samira is the only one not participating in the dance/music excitement.
> [Samira seems alienated from her classmates' pop music performance; the only one who does not seem entertained by it. She seems embarrassed to be around and moves away slightly when they are singing the song very loudly.]
> Everyone claps. Mr Cohen is very pleased with their work. 'Brilliant work, you guys!' (Observations, NS class visit, November 2014)

Creating songs and choreographies to present museum objects has similarities with what Calabrese Barton et al. (2012) have discussed through the notion of 'identity artefacts'. Identity artefacts include instruments, such as material tools, embodied spaces, texts and discourses that mediate identity-shaping activities. The authors have argued that identity artefacts can be powerful for helping young people negotiate the process of engaging with science and can be particularly influential for students who otherwise struggle to leverage their resources in the classroom. In their study, the opportunities students took to engage with science, e.g., through creating a 'make a change' video, drawing on their creative skills like drawing, acting and dancing, were able to assist them in gaining voice, authorship and recognition within science. Other research has demonstrated that valuing and legitimising non-dominant forms of resources that students possess can contribute to engagement with science in multiple and varied ways (Calabrese Barton et al., 2008; Gonsalves et al., 2013; Tan, Calabrese Barton, Turner, & Gutierrez, 2012). For many young people, particularly those who feel marginalised in the science classroom, opening up or shifting the field to encompass broader opportunities and to value a wider range of resources may provide crucial moments in igniting their engagement with science.

The filmed presentations that the girls performed during the class visit to the science museum also contributed to how they were recognised by their teachers. Alimah, for instance, rarely participated during the science lessons and was described by Mr Cohen as 'not doing amazing at it [science]'. Following their presentation about the Apollo 10 exhibit, he loudly complimented their 'brilliant work'. I argue that for someone like Alimah, who received little recognition in the classroom, this could have played an important role in how she identified with science. As Carlone & Johnson (2007) have contended, recognition is a key element shaping science identity. I would say that by explicitly recognising Alimah's performance, Mr Cohen may have positively contributed to shifting her science identity trajectory. Other teachers mentioned during the follow-up interviews that they were impressed by the extent to which the girls got involved with the filming activity and science during the visit. Mr Bramley, in particular, mentioned that he was surprised by the change in some of the girls who rarely engaged during the science lesson. The following excerpt illustrates Mr Bramley's response to Cordelia's engagement with science during the class visit.

> Mr Bramley: 'Cordelia at the back [of the classroom], she's one of these who "can't, like, I don't understand this, I don't want to do it" and I say, you know, this is the Cordelia that was like rapping and doing all sorts of things in the museum.' […]
> SG: 'Is she normally not that into science when you are in class?'
> Mr Bramley: 'I mean, she did actually surprise me that, you know, quite a few things she was saying going round, that she had actually been there before. I just probably thought, you know, from the impression she gives, I think it's not science in particular, it's just school in general sort of thing that she might have a problem with, you know, but certainly I didn't notice that while going round [referring to the class visit]'. (June 2015)

I interpreted Mr Bramley's comments as suggesting a newfound recognition of Cordelia's engagement with science, which he had not previously noted at school. While I do not have data to indicate that this recognition was made explicit to Cordelia, I suggest that a shift in how Mr Bramley saw this girl (i.e., as someone who was keen on science, but who may have had a 'problem' with the science she encountered at school) may have impacted on her beyond the visit. It is difficult to say to what extent the recognition that the girls received during the class visit to the science museum shifted their identification with science, or made a difference regarding their general engagement with it. Following a Bourdieusian perspective, it would be unlikely to expect that a moment of engagement and recognition could have significantly shifted the girls' habitus towards/against science, as this is framed as a set of durable dispositions (Bourdieu, 1977b). Yet, science education studies have somewhat more optimistically argued that such engagement and recognition moments can play a crucial role in shifting students' trajectories (Calabrese Barton et al., 2012; J. Thompson, 2014). Calabrese Barton et al. (2012) have argued that a shift in science identity trajectories occur when, for instance, 'a girl comes to view herself in science in a different way and others come to view the girl in a different way while engaging in science-related activities at particular moments' (p. 68). While the data I was able to collect as part of this study do not enable me to examine the more substantial changes resulting from these moments, I would contend that these moments were, nevertheless, valuable and point to what engagement with science might be possible (at least in the moment) when the field shifts to include broader resources and behaviours as being 'scientific'.

Finally, the data from the class visit highlight that while broadening the field may have contributed to enabling engagement with science for some students, the shift made engagement problematic for others. As the above excerpt from the observation notes illustrates, Samira appeared to be uncomfortable with her classmates' performances of singing and dancing. As a result, she withdrew by physically distancing herself from her group. I suggest that the shift that made a broader range of resources valuable and recognised as 'scientific' also meant that Samira no longer stood out in the class to the extent she did in the science lessons. This, I propose, at least in that moment challenged her recognition as the emblematic 'science person' in her class. It is difficult to say, however, whether this occasion had more substantial implications for Samira's engagement with science.

The findings from a study conducted by Carlone (2004) in a secondary school in the US offer some possible interpretations for Samira's case and why widening celebrated ways of doing science might constrain engagement with it for some students. In her study, Carlone observed students involved in the 'Active Physics' curriculum that aimed to challenge the prototypical meanings of science/physics by drawing on everyday issues. This approach succeeded in engaging some of the students, but a group of high achieving girls resisted the newly promoted ways of doing science. They were successful in the mainstream ways of doing science and (similar to Samira in this study) struggled to embrace the shift in the field of school science that challenged and weakened their celebrated position. The resources they possessed were no longer the most valuable 'cards' in the 'game' of science education, to borrow from Bourdieu's language. Samira's case is also interesting from the gender perspective (i.e., the filming activity appeared to have celebrated the performances of hyper-heterofemininity that otherwise tended to be in tension with science). I discuss these data further through a Butlerian lens in Chapter 6.

5.5 Usefulness of the theory of social reproduction for understanding engagement with science in practice

Drawing on Bourdieu's theory has been useful for examining the girls' engagement with science in practice, because it provided the tools to investigate how the field of school science was constituted and what this meant for the girls' habitus and capital (i.e., the degree to which they were aligned). Bourdieu's work provided useful guidance regarding how to analyse a field, recommending attending to the relations between actors and their habitus/capital (Bourdieu & Wacquant, 1992). In the case of this study, this meant considering the relations between the girls and their science teachers. The analysis of the norms and expectations in the field of school science enabled me to examine what behaviours were legitimate and celebrated within the field and which were those that incurred tension. Through the concepts of capital and habitus, Bourdieu's theory enabled me to examine the role of the girls' social class, which is considered to be an elusive construct that is difficult to determine empirically (Davey, 2009).

5.6 Summary

In this chapter I have used a Bourdieusian analytical lens to examine the girls' engagement with science during science lessons and class visits to the science museums. I began with the argument that the two largely constituted the same field. I suggested that the change in a physical setting (i.e., the girls going to a science museum with their class) was not sufficient to enable different opportunities for engagement, because the relations between the students and the teachers, along with the norms and expectations, mostly remained unchanged. Given this finding, I explored the two together. I examined the dis/alignment between the girls' habitus and capital and the field, leading me to contend that science lessons and class visits offered opportunities for engagement with science only to a few girls, who behaved and participated in ways that were expected and celebrated by the field. Behaviours that were in conflict with the field (such as speaking science in ‘inappropriate’ ways) resulted in tension, which consequently constrained the girls’ engagement with science. While the norms and expectations mostly translated to the science museum visits, the visit also offered brief moments of opportunity for engagement with science in different ways. This occurred when the field shifted to enable and value broader ways of doing science. Such opportunities, however, whilst opening new ways of doing science for some, made engagement with science more difficult for others.

Chapter 6: Gender analysis of girls' engagement with science

6.1 Introduction

In Chapters 4 and 5, I examined the girls' engagement with science through a Bourdieusian analytical lens. I now further unpack the patterns of engagement with science through a Butlerian lens. I continue to address both research questions: **How do interactions of gender, social class and ethnicity shape girls' preliminary engagement with science?** and **How do interactions of gender, social class and ethnicity shape girls' engagement with science within lessons, class visits and family visits to science museums?** In this chapter, I put at the forefront gender and also consider interactions of gender with other social axes. I draw on the data from across the dataset, with the exception of those related to the family visits to the science museums, which are the focus of Chapter 7.

In the first part of the chapter, I examine how the girls constructed science as a gendered subject and what these discourses meant for their identification with science and their aspirations. I also provide evidence of how some of the girls challenged the dominant discourses of science as masculine/'for boys' in order to make science possible for them. I discuss the analysis of data from the initial and follow-up focus groups and interviews with the girls, which I combine with their teachers and parents' perspectives. To analyse the gendered discourses, I draw on the post-structural feminist and education literature, along with the dominant binary model of gender and typically feminine and masculine attributes.

In the second part, I explore how the girls' gender performances (Butler, 1999, 2004) enabled or constrained their engagement with science in practice and how these performances were recognised by their teachers in regards to the subject. I put at the forefront data from the observations of science lessons and class visits to the science museums, which I discuss along with the girls and teachers' accounts of their experiences and discussions about science and gender performances. To analyse and discuss the data, I draw on the gender analytical framework that I outlined in Chapters 2 and 3, including performances of hyper-heterofemininity, restrained heterofemininity and muscular intellect. I conclude the chapter by discussing the usefulness of the selected gender theoretical approach for examining the girls' engagement with science.

6.2 Gender and preliminary engagement with science

The girls almost unanimously rehearsed an egalitarian discourse that science was 'for everyone' and that anyone could do science. They spoke about it as being independent of the person's gender or social background. Alimah, for example, said that it was 'not about what gender you are, you have to learn the stuff [to do science]'. Rifat, further, mentioned that science was for both boys and girls, arguing that it was 'rude' to suggest otherwise, as the following excerpt demonstrates.

> Rifat: 'Science is for both boys and girls; it's not like only boys can do science. […] I know it's like stereotypically going that men are more likely to become scientists than women, but to be honest, science is for everyone. It doesn't really matter if you're male or female if you become a scientist or not. It is kind of rude [to ask] actually…' (Focus group, March 2015)

The girls' responses to the gender-related questions, as illustrated by Alimah and Rifat's comments, combined discourses of equal opportunity and individuality. They considered science to be equally accessible to girls and boys, thus regarding success in science as depending solely on a person's individual efforts. This meritocratic view is not surprising, as research has previously found that students often hold the views that boys and girls are granted equal rights and opportunities in education and the job market (Francis, Burke, & Read, 2014). Previous research work, however, has also found that students' apparent meritocratic views rarely extended to all students and all trajectories and that the view of equal opportunity was particularly common among boys (Francis, 2000b; Francis et al., 2014).

Despite the views that people could pursue whatever trajectory they wanted, the findings of this study suggest that the girls' aspirations largely followed gendered patterns. 10 out of the 15 girls reported aspirations that I categorised as science-related (see Table 3-6). Only two of the girls aspired to pursuing science-related professions in male-dominated areas. Rifat and Aliyah said that they wanted to become games designers, which I interpreted as aspiring to work in an industry where women represent a minority (i.e., around one fifth) of the total workforce (Creative Skillset, 2016). Five[11] of the girls aspired to working in occupations related to nurture and care; those where women's participation generally tends to be relatively equal or greater than men's, e.g., medicine, pharmacy, medical research and midwifery. When elaborating upon their aspirations, the girls spoke explicitly about being attracted to working with people and being able to help people and animals.

Girls' construction of science as masculine and more 'for boys'

The girls' views of science as 'for everyone', however, were often articulated alongside more complex and nuanced gender discourses, particularly when they considered their own positioning in science, rather than a general idea of who might choose, identify with and aspire to working in science. Most of the girls associated at least some aspects of science with masculinity. This association was either explicit, such as their remarking on the fact that there are more men than women in science jobs, or implicit, such as the girls associating science and science people with typically masculine traits. The following excerpt from a focus group with Layla and Rifat illustrates the view that science was seen as a male domain.

> Layla: 'Most famous things that have been discovered were discovered …'
> Rifat: 'By male people!'
> Layla: 'Yeah, so I think this is why when people say scientist you think of a man. Most famous scientists are male.' (Focus group, June 2014)

Similar remarks were made by the girls across the cohort. Samira acknowledged that 'there are more scientists that are boys than girls' and Dorota remarked that 'many of the great scientists are boys' and that boys were 'more famous for some

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[11] Three girls did not specify their aspiration beyond doing something related to science or science research.

reason'. A greater visibility of men in science appeared to have normalised the thinking that boys were more likely to get into science than girls, as the following quote from Cordelia suggests.

> Cordelia: 'I think that most like men want to be scientists, if they go down the right path, because like the technicians in our school, they're not women, they're men. And when you hear of, like, Einstein and people like that, they're not women and mostly in films as well, like working with computers and stuff, looking at space … they're all men.' (Focus group, March 2015)

Cordelia's remarks reflect the dominant notion of science as male-dominated and point to the media representation of science and scientists that tend to reproduce the images of the latter as being predominantly male (e.g., Cheryan, Plaut, Handron, & Hudson, 2013). I suggest that such perceptions of science may have contributed to Cordelia's dis-identification with science; despite her planning to study biology and to become a midwife, she resisted identifying with the subject.

The girls' constructed a discursive distinction between 'feminine' (easy, caring) science and 'masculine' (hard/difficult, technical) science (see Moreau & Mendick, 2012 for a discussion on the notion of 'feminine' science in online spaces). The following quote from Rifat, similarly, shows how she framed science in relation to boys and girls' interests, values and occupations. She related physics to typically men's interest in cars (technical) and biology to typically women's professions like nursing (caring).

> Rifat: '… you need like physics and all that for cars and stuff like that. You know, typically boys like cars, they like all this and stuff … Biology is more like human, you can become doctors and stuff like that with biology and then you see like female nurses and all that.' (Interview, June 2015)

The distinction between physics as more for boys and biology as more for girls is consistent with and reproduces the dominant gendering of school science subjects, whereby physics is regarded as the most masculine among these subjects (Harding, 1991; Hughes, 2001; Keller, 1992; Walkerdine, 1990). This dominant gendering of science subjects has also been reflected in participation figures, which have repeatedly shown that girls' participation is the lowest in physics and the highest in biology (Elias et al., 2006; Institute of Physics, 2013; Smith, 2011a), as I discussed in Chapter 1. Hughes (2001) has also previously noted that physical sciences are particularly incompatible with femininity, making a subject like physics especially difficult for girls to engage with.

Some aspects of science and some science-related careers were seen by the girls as suitable for both boys and girls, while others more for boys. Sharifa, for instance, mentioned that while gender did not play a role in relation to becoming a science teacher ('I think it's the same for girls and boys, they can do the same thing in science, like if you want to be a science teacher you can be a girl or a boy, it's no different…'), engineering was a different story.

> Sharifa: 'Boys, they like to get dirty, depends on their personality though, but then some girls don't like to get dirty and then engineering, you will get dirty and stuff, you'll get like all messy, but then boys, they don't really mind, they just like, they just get on with their job. Girls, if they get something on their clothes, then they start moaning...' (Interview, April 2015)

Sharifa associated engineering with 'getting dirty' and hence, I would argue, less 'intelligible' for girls (Butler, 1999, 2004). By speaking about girls this way, I suggest that Sharifa may have attributed these qualities to herself (Due, 2014), consequently implicitly positioning herself in tension with 'dirty' engineering. There was thus, a dichotomy between 'feminine' science, which was constructed by the girls as 'intelligible' for them and 'masculine' science, which was 'unintelligible'.

The girls' perceptions of science as masculine appeared to have also been shaped by their experiences of school science. As I began to discuss in Chapter 4, many of the girls associated science with being hard/difficult and 'science people' with cleverness, academic achievement and rationality. For instance, Samira commented that a 'science boy' in their class was a combination of a calculator and a dictionary, whilst others girls mentioned similar traits. In the education literature, cleverness has been argued to be associated with masculinity (as well as classed and racialised) (Archer, DeWitt, et al., 2013; Archer & Francis, 2007; Francis & Skelton, 2005). Following the traditional Western construction of femininity and masculinity, girls' association of science with cleverness and rationality contributes to science being symbolically included within the masculine sphere and therefore, less easily available to them than to boys. The girls' discourse of 'science people' as clever, I suggest, may have played an additional role in their identification and aspirations *against* science.

School science also appeared to have included fewer typically feminine interests, offering limited opportunities to the girls to draw on resources that were aligned with feminine characteristics. Mr Cohen commented that as a teacher, he tried to attend to student diversity in his classes and consider issues like gender, but admitted that the schemes of work he had to follow tended to include typically boys' interests more commonly than girls'.

> Mr Cohen: 'A lot of the topics we teach are quite boy-centred. I mean, we have to think about what we can do to involve all students, gender and interest, background, whatever, but it's hard to get everyone every time. So, there are some topics that are more tailored for female students than male … Day to day, we don't think about it deeply, to be honest, we use the scheme of work, but we do think about a particular activity that you might add in. But yeah, a lot of our schemes of work are quite male centred, they appeal to boys more than they do to girls.' (Interview, July 2015)

The notion that the science curriculum and schemes of work tend to be oriented towards boys' interests more than towards girls' has been discussed in previous research work (Osborne & Dillon, 2008; Sjøberg & Schreiner, 2010), highlighting the difficulties for many girls to engage with science.

The gender analysis, furthermore, highlighted that there was a gendered aspect to science capital. Some of the girls, for instance, considered science-related resources and interests that I interpreted as aligning with femininity (e.g., interest and knowledge of animals) as having lower value, even dismissing them as 'not-science'. Caitlin spoke about having an interest in animals and when prompted, said that she had considered becoming a veterinarian as a back up to her career in entertainment. Yet, she appeared not to see any relation between animal work (as well as medicine, see Chapter 4) and science. Catlin appeared to have distanced her animal work from science, which she constructed as narrowly encompassing topics and activities from her science lessons, such as laboratory work, as I discussed in Chapter 4. A similar paradox of being keen on and interested in animals/biology, but simultaneously rejecting science, has been previously noted by Zimmerman (2012), who found that some young people participated in science-related activities (i.e., recognised as science from the dominant perspective of what science entails) without calling these activities 'science'. She has raised concerns that by not recognising their practice as science or even distancing themselves from the subject as they differentially framed it, these young people struggled to consider themselves as 'scientific'.

By not recognising their resources (interest, knowledge, hobbies) as science-related, I suggest that these resources had limited value to the girls in supporting their engagement with science. These findings extend the discussion on the role of science capital that I began in Chapter 4 and emphasise the importance of contexts for making some resources valuable, while rendering others less so. I suggest that forms of science capital associated with typically masculine traits and interests, such as technology and engineering, were perceived by the girls as having higher value within the dominant field than that science capital typically associated with femininity, such as Caitlin's interest and experience of working with animals. These findings are important, because they highlight that science is not a neat construct with a definition that everyone agrees with nor do all of its aspects of science have the same value within the dominant fields. Further to the ethnic aspect of science capital that I discussed in Chapter 4, this chapter contributes to highlighting a gender one.

Resisting the dominant discourses of science as masculine

The above findings that the girls perceived science as masculine is not surprising, as similar findings have been reported by previous studies (Brickhouse, 2001; Lemke, 2001; Osborne & Dillon, 2008). A novel contribution of this study is the ways in which the girls who identified with science and aspired to having science occupations *resisted* these dominant discourses. Four girls (Amna, Asqa, Dorota and Samira) spoke about science in ways that I interpret as challenging the dominant discourses of science as 'not for girls' along with articulating egalitarian discourses that it was for everyone. In this subsection, I discuss three strategies demonstrating how the girls in this study resisted these discourses: (i) reframing science as nurturing and caring; (ii) challenging gendered structure of science; and (iii) rendering gender invisible.

Two girls reframed 'science people' as aligned with traditionally desirable feminine attributes of nurturing and care (Francis, 2000a, 2005). Asqa and Amna both aspired to pursuing careers in science; the former in medicine (doctor, dentist or pharmacist) and the latter in science research. Asqa described 'science people' as those who liked to 'help people, like they want to save lives' and Amna associated them with people who cared about animals and the environment. Below is Amna's response to how she would describe science people.

> Amna: 'I think people who are like … who care about the environment and everything and who are like really eco-friendly. I think they care a lot about science because obviously science teaches you about the environment and like the animals and everything.' (Interview, June 2015)

The notion of help and care appeared central to these girls' construction of 'science people'. I suggest that such reframing enabled these two girls to construct 'science people' as gender 'intelligible' (Butler, 1999, 2004) and hence, possible to enact by girls who perform heterofemininity (see section 6.3 for gender performances).

This finding is important, because previous studies have argued that girls' perception of science as non-nurturing and non-caring (and therefore, non-feminine) presented a challenge for many girls in relation to identifying with science (Archer, DeWitt, et al., 2013). The science education literature has mostly discussed girls' science identity negotiations through their performing femininity in less visible ways. Previous studies have found that most 'science-keen' girls who aspired to science-related careers perform 'modest' rather than excessive versions of femininity (Archer et al., 2012a). Another study has suggested that performing acts of 'laddishness'[12] enables women to fit better into the masculine and male-dominated domain of physics (Danielsson, 2011). In contrast to this research work, two girls in this study negotiated their science identities through constructing 'science people' as more feminine, better aligning the performances of science and femininity in this way. While it appears promising that Amna and Asqa were able to identify with science in this way, however, concerns remain as to whether this strategy could enable long-term engagement with science as well as whether it would enable engagement with highly masculinised areas, such as physical sciences.

Secondly, one girl challenged the discourse of women's absence from science achievements by drawing on examples of successful female scientists. While several girls spontaneously mentioned women's past achievements in science, Dorota stood out in terms of her agency and resistance to the dominant discourse, such as by highlighting the achievements of her role model Marie Curie.

> SG: 'Do you think boys are more likely to go into science than girls, what do you think about that?'
> Dorota: '… it is stereotypical to think that because many of the great scientists are boys, but then there's also scientists like, I think her name's Madam, oh God, the one that found out about cancer through getting radiation or something, Madam Curie or something like that…'
> SG: 'Marie Curie?'
> Dorota: 'Yeah, so she's also a big inspiration to me, because she's a woman and all that, so I don't think boys are more likely, I just think that boys are more famous for some reason, I don't know why, but…' (Interview, June 2015)

This quote suggests that Dorota was trying to resist the dominant stereotypical discourses, but she also seemed to have found it discursively challenging. For

[12] 'Laddishness' refers to hegemonic masculine performances typical for working class boys. They involve, for example, 'having a laugh', alcohol consumption and disruptive behaviour (Francis, 1999; C. Jackson, 2003).

instance, she forgot the name of the female scientist and was not sure why boys are more famous in science than girls. I suggest what while Dorota appeared to want to resist, she may have lacked the capital to do so. Further, school science appeared to offer little support for girls like her to learn more about women in science. Dorota's science teacher, Mr Bramley, for instance, admitted that making science better suited to girls in the science lessons was not an easy task for him and that he had previously struggled to incorporate references to female scientists into his science lessons. I suggest that with little support at home and school, it was difficult for Dorota to obtain the relevant knowledge that would better support her aspirations in science.

The third strategy carried out to make it possible to participate in science was rendering gender invisible. This strategy was suggested by Samira's comment about her experience at the school's STEM club, where she was often the only girl. To my surprise, she said that she had not noticed this until I asked her about it and speculated that no one in the club noticed gender.

> SG: 'What's the ratio of boys and girls in the [STEM] club?'
> Samira: 'More boys than girls, I think. Sometimes I'm the only girl but yeah […] but like they come sometimes, but not always, but I usually go like regularly.'
> SG: 'How does it feel to be the only girl in the STEM club?'
> Samira: 'I didn't really notice until you asked me, because I didn't really, I don't think anyone really notices, because we're all like into science, it's not about gender, it's more about the learning part of it.' (Interview, March 2015)

While Samira's view that science is independent of gender-affiliations and gendered bodies appears positive, in that it enabled her seemingly unproblematic participation in the STEM club, I suggest that rendering gender as invisible might be challenging in other ways. First of all, as Harding (1986) has argued, 'there are no contemporary humans who escape gendering' (p. 57) and therefore, I question whether Samira's strategy would be successful in the long run. As has been argued in the feminist post-structuralist literature, society 'expects' males and females to perform in accordance to their physical sex. Once a person is identified as female, her behaviours are judged by people around her with a reference to this attribution

(Francis, 2012; Kessler & McKenna, 1978), which I suggest makes it difficult to imagine how Samira's strategy could be successful in the future.

Samira's case has parallels with findings of a previous study carried out by Gonsalves (2014), who explored the experiences of female physics students, which highlight additional potential challenges for someone pursuing Samira's strategy. Gonsalves has reported that in some instances, female physicists in her study failed to be recognised by their lab colleagues as (ordinary) women, which she interpreted as there being little space for a female physicist to be recognised as both a woman and a physicist in the lab. Samira's comment that no one noticed gender in her STEM club might, similarly, bring into question to what extent it enabled a space where one could both 'do girl' and 'do science'.

In conclusion, gender played an important role in shaping the girls' preliminary engagement with science, but not in a straightforward way, e.g., all science being more for boys. The processes of how the girls negotiated their ideas about gender and science were complex and multifaceted, with their identifying with some aspects of science, but not with others and valuing 'masculine' science and associated resources more than those pertaining to femininity. Most of the girls who identified with science spoke about it in ways that I interpreted as challenging the dominant discourses of science as masculine. While this appeared to have made it possible for them to negotiate their performances in science, however, their discourses raise concerns about the sustainability of these strategies and their potential for the inclusion of all science.

6.3 Gender performances and engagement with science in practice

In this section, I examine how the girls performed gender during their science lessons and class visits to the science museums. I also consider how these performances facilitated or constrained their engagement with science. Following the gender analytical approach I outlined in Chapters 2 and 3, I coded the girls' performances into three broad categories; hyper-heterofemininity, restrained heterofemininity and muscular intellect. I begin by outlining their performances of gender within each physical setting and then discuss how these supported their engagement with science and how they enabled the girls to be recognised by their teachers.

During the science lessons, I observed eight girls consistently performing acts that I coded as hyper-heterofemininity; these included investment in physical appearance, flirting with boys (in the Northfields School mixed class), singing and socialising with their peers. In the wider literature, these performances have been associated with the working class and considered to be in tension with education and academic achievement (Archer & Francis, 2007; Archer, Halsall, et al., 2007a; Reay, 2001b; Renold, 2005; Skeggs, 1997, 2005b). Eight girls performed versions of heterofemininity that were more restrained; these included the absence of the more sexualised performances of heterofemininity in favour of quietness, passivity and 'good girl' behaviour. The wider literature has associated these performances with middle class and considered them to be somewhat better aligned with education (Francis et al., 2010; Reay, 2001b; Skeggs, 2005b; Walkerdine, 1990; Walkerdine, Lucey, & Melody, 2001). The girls in this study, however, were not middle class (with one exception) and I discuss below how these performances were shaped by the interaction with ethnicity. Finally, two girls occasionally performed muscular intellect alongside performances of restrained heterofemininity, which included performances of loud and confident displays of knowledge, typical for high attaining middle class boys (Francis et al., 2010; Redman & Mac an Ghaill, 1997). The girls' performances were not always bounded and distinct. I focused on what acts the girls were preforming *most of the time*. Figure 6-1 illustrates the girls' gender performances during science lessons.

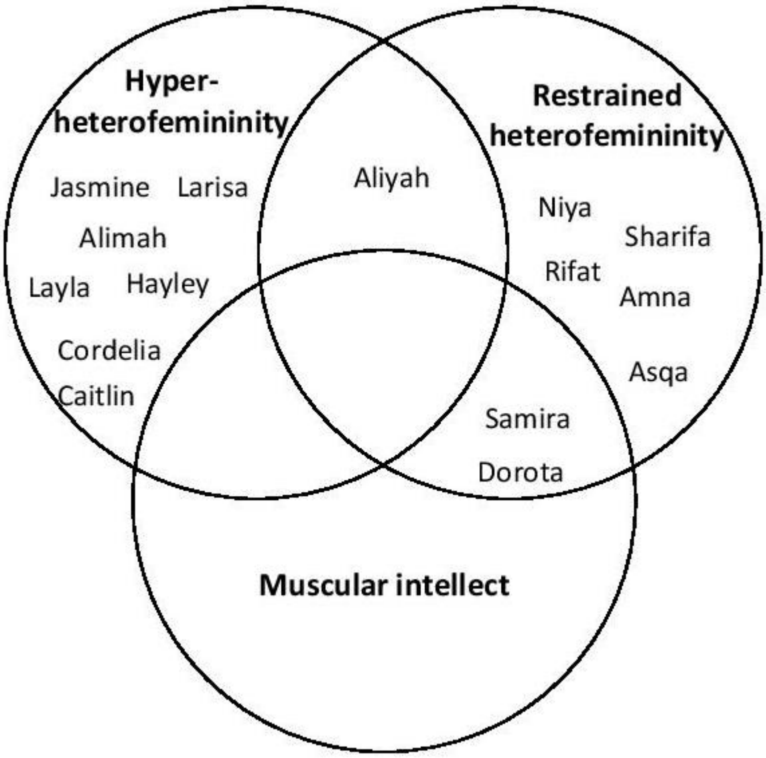

Figure 6-1: The girls' gender performances during science lessons

The class visits to the science museums appeared to enable more opportunities for the girls' various performances of gender. This was evident through a wider range of behaviours observed during the visits. Four additional girls enacted performances of hyper-heterofemininity (Amna, Asqa, Dorota, Rifat), such as through spending time taking selfies (instead of doing work) and socialising. As Johnson, Brown, Carlone, & Cuevas (2011) have suggested, students 'perform combinations of behavior, speech, and artefacts perceived as "appropriate" as they enter new settings' (p. 344). Figure 6-2 illustrates the girls' gender performances during class visit to the science museum, with the names of the girls whose gender performances shifted underlined.

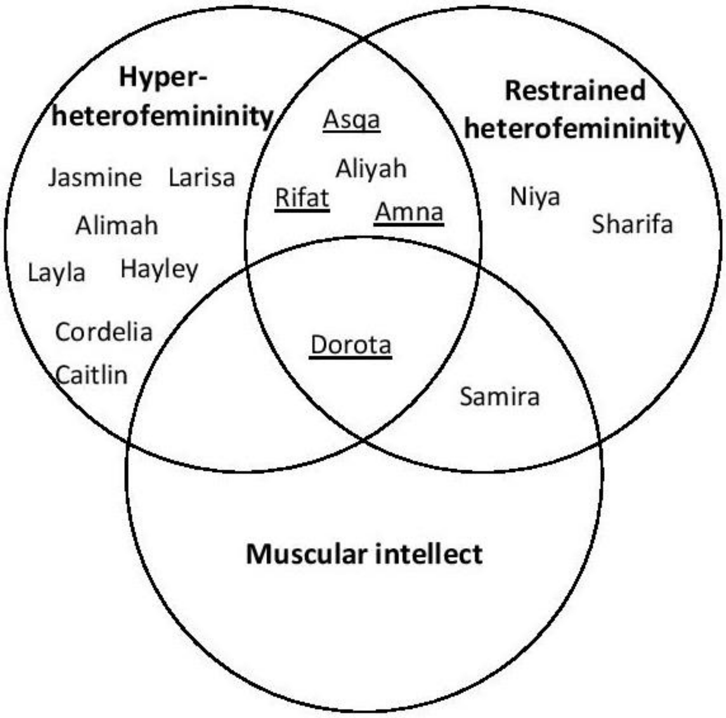

Figure 6-2: The girls' gender performances during class visits

Hyper-heterofemininity in tension with science

Performances of hyper-heterofemininity during science lessons and the class visits to the science museums appeared mostly to be in tension with science or were enacted in ways that I interpreted as disengagement from science. For instance, the girls avoided doing schoolwork during their science lessons in favour of flirting, socialising, singing and investing energy in their physical appearance (making hairstyles, using makeup, pretending to wax body hair). The following examples from the observation notes illustrate a few of these instances. I coded these performances as disengagement from science because they were enacted at the time when the girls were instructed and expected to participate in schoolwork.

> Cordelia finds some sticky tape and tapes her nose down, makes funny faces to others. [...] Cordelia is pretending to use sticky tape to wax her upper lip. (Observations, LH science lesson, March 2015)
>
> Caitlin is swinging in her chair. […] Caitlin is spending a lot of time sorting out her long blond hair, making different hairstyles. (Observations, NS science lesson, July 2015)

> Jasmine is singing and dancing in her chair, playing drums on the table. […] Jasmine starts singing in a high pitch voice, teases [male name] who is playing with the big nails (part of the experiment). (Observations, NS science lesson, July 2015)

Through performances of hyper-heterofemininity, the girls were relating to their classmates. They sought their attention (Cordelia's case) and interacted with them through flirting and socialising (Jasmine's case). It has been suggested by previous studies that working class heterofemininity often tends to be enacted as a way to gain peer popularity, whereby these performances serve as a strategy to obtain symbolic capital (Archer, Halsall, et al., 2007a; Skeggs, 1997).

The association of performances of hyper-heterofemininity with popularity, was also stressed by the participating science teachers. Mr Cohen, for instance, commented on the group of girls in his class, who were part of a 'Beyoncé group' (which Alimah described as 'we all like Beyoncé and we all like to sing Beyoncé songs' and by Mr Cohen as 'five of them who play around, flirting with boys'; including Jasmine, Alimah, Caitlin and two other girls from their science class who did not take part in the study). He said that these girls mostly focused on being 'happy and having fun' and speculated that they were more concerned with their popularity rather than education, adding that none of them has been very engaged with school science. The wider education literature has discussed how peer popularity tends to be in tension with educational achievement and that academically successful students often carefully manage their academic performances with maintaining popularity (Francis & Skelton, 2005; Francis et al., 2010). By associating performances of hyper-heterofemininity with negative attributes, I would argue that teachers may have 'other[ed] femininity as deficient in its superficiality' (Francis et al., 2010, p. 326). As Carlone, Johnson, et al. (2015) have contended, narrowly constructed norms and values permeating science education leave 'virtually no room to be simultaneously "girly" and "scientific"' (p. 474).

In this study, performances of hyper-heterofemininity appeared rarely to enable the girls' to engage with science. This was evident in the absence of data on girls performing both simultaneously as well as in the instances of explicit tension between these performances and science. Ms Richards, for instance, spoke about Hayley as someone who thought she was 'quite cool' and who therefore, 'didn't want to be seen as being into science'. I interpreted Ms Richards's remarks as suggesting that 'coolness' and 'science' were antithetical. Hayley agreed that she was 'quite girly' and she added, 'I like to dress up a bit, obviously I like to look after myself'. In the follow-up teacher interview at the end of the school year, Ms Richards spoke about being surprised that Hayley came to the project family weekend (see Chapter 7) and that she was participating in the school's end-of-year science fair. Despite interest and engagement with science, Hayley appeared to have consistently struggled to gain recognition for being 'scientific', which is why I argued in Chapter 4 that her preliminary engagement with science was 'problematic'. Hayley's case was reminiscent of the girls and women's struggles in science discussed in the wider science education literature (Carlone & Johnson, 2007; Malone & Barabino, 2009), where girls and women who do not get recognised as 'scientific' tend to find it difficult to position themselves in science and to see themselves as belonging in the discipline.

During the class visits, similarly, the girls' performances of hyper-heterofemininity rarely enabled them to engage with science (with one exception, which I discuss in the next subsection). Most of the girls (11/14) were observed doing performances of hyper-heterofemininity at some point during the visit. Further to behaviours I observed during the science lessons, the museum visit also enabled new and different opportunities for behaving in particular ways and being involved in various activities, such as physically hiding from teachers and taking 'selfie' photographs[13]. Students were given cameras as part of the project to record

[13] A selfie photograph is a self-portrait photograph, typically taken with a digital camera or camera phone held in hand. Selfie photographs are often shared on social networking websites (sources: Wikipedia, Urban dictionary).

presentations about the museum objects, but taking such photographs quickly became a predominant activity that continued throughout the visit. As has been discussed in the project literature elsewhere (Dawson et al., 2016), participation in taking selfie photographs tended to go hand in hand with reviewing the images and selecting the 'best looking' ones, which served to negotiate spaces of popularity and social desirability. The following excerpts from the observations notes taken during the class visits illustrate how taking 'selfies' was organised among the girls.

> Aliyah and Caitlin talk about selfies – Aliyah says 'I took a selfie with the boy I like' – has to repeat a couple of times, as Caitlin is distracted by other exhibits. 'Let's take a selfie' says Aliyah, Caitlin says – 'I'm going to post it to Instagram.' (Observations, NS class visit, November 2014)
> Rifat: 'It's time to take a selfie!' but then decides to take a photo of girl1 first instead. […] Girl1 looks at them afterwards 'Ugh my face looks horrible!' Rifat runs off with the camera, giggling. (Observations, LH class visit, March 2015)

These observation notes were taken while the girls were in the middle of science activities. Hence, I argue that the girls engaged in these behaviours as part of avoiding work. Aliyah and Caitlin were chasing their male classmates and taking photographs during the activities in the interactive gallery. Rifat and her partner, similarly, spent most of their time taking and reviewing selfies when instructed to participate in an 'object hunt' activity (finding and photographing museum objects that fitted particular criteria).

When performances of hyper-heterofemininity accidently coincided with science, the outcome suggested that the two did not seem to fit together 'naturally'. In one such instance that I observed, a group of girls taking a selfie by chance included an image of a large airplane engine in the backgrounds, to which Asqa responded loudly upon reviewing the image 'Oh my god, we're taking selfies with engines!'. I interpreted Asqa's reaction as conveying a sense of surprise, suggesting the juxtaposition of selfies (hyper-heterofemininity) and science/engines (masculinity). The two were not configured in the same way, thus their proximity and co-existence seemed out of place. It is difficult to say from the available data, however, whether this instance had further implications for the girls' engagement with science during their visit.

Being engaged with science appeared to be in tension with peer popularity. This was suggested through the girls' explicit rejection of science as a strategy for peer popularity. A group of girls from Northfields School, who spent most of their visit running around and hiding from their teachers, were recorded having the following conversation.

> Jasmine (speaking into the microphone attached to her jacket, sarcastically): 'This is really cool. I think today was really fun, because we didn't get so many adults to follow us. And I think I learnt a lot today. It was really fun, don't you think Sharifa?'
> Sharifa: 'Yes. It was fun innit?' […]
> Jasmine: 'It was too fun. I would vomit, it was so much fun.' [Two other girls who stand close giggle.] (Observations, NS class visit, November 2014)

I interpreted this instance as the girls mocking engagement with science and schoolwork, in order to fit in socially. As others have noted, there are 'inherent tensions between heterosexual attractiveness and academic success within wider public discourse' (Archer et al., 2012a, p. 977). I therefore suggest that the association of science with cleverness and thus, masculinity made it particularly difficult for the girls to engage with. Studies have also argued that there might be a particular struggle for girls to 'do girl' and 'do science' successfully (Archer et al., 2012a).

In the follow-up focus groups and interviews, the girls spoke about the behaviours and activities that I categorised as fitting within hyper-heterofemininity (taking selfies, chasing each other, socialising) as highlights of their visits to the science museum. When asked about whether they talked to any friends or family about the visit afterwards, Caitlin mentioned instantly 'I spoke to my parents about it because we took so many selfies' (she also commented that the first thing her mum asked her about the science museum visit was whether she had taken any selfies). Other memorable moments from the visit to the science museum that the girls spoke about included 'playing a lot' (Alimah), 'playing hide and seek' (Jasmine) and 'running around' (Alimah, Jasmine). At the same time, the girls were able to remember very little about the museum objects or science they encountered during their visit.

The girls' reflections of the visit in the follow-up interviews and focus groups further suggested the tensions between science and popularity. Samira, who was most of the time strongly engaging with science, attempted to reposition herself as not interested in science during the follow-up focus group (conducted with a group of five girls) and denied that she had participated in science-related activities during the science museum visit. For instance, she mentioned that her ideal class visit would be organised around opportunities to 'have fun and to take selfies and to run around the place' and that the visit could have been better with 'no writing in notebooks and having to do work'. These comments were in a stark contrast with her behaviour in the museum that I observed, where she consistently engaged in science-related conversations with her teachers and museum educators, urging her peers to 'do work' and write in their notebooks. Hence, I would contend that there was a tension between a desire to fit in socially and engaging with science. Further, Samira's attempts to reject her engagement with science could exemplify her monoglossic masking of gender heteroglossia (Francis, 2012), whereby she pursued the impression of monoglossic gender stability (doing femininity) to mask possible inconsistencies in gender performances (resulting from doing science).

Hyper-heterofemininity enabling moments of engagement with science during the class visits to the science museums

Despite hyper-heterofemininity mostly being in tension with science, one particular activity stood out during the class visit to the science museum in terms of opening up the ways for the girls to engage with science through performing these acts. This was filming the presentations about selected museum objects, which I had begun to discuss in Chapter 5 in terms of the field having shifted to recognising and valuing a wider range of resources for engaging with science. I argue here that this activity not only enabled the girls to leverage resources that appeared to have little value and recognition within a typical science lesson, but also that this activity enabled the girls' engagement with science *through* performances of hyper-heterofemininity.

This activity, at least to some extent, provided an opportunity for the girls to 'do girl' and 'do science'. This took the form of the girls singing and dancing to songs they created to present the museum objects. Four girls (Larisa, Alimah, Cordelia and Layla), in particular, were observed organising their presentations around links to pop culture and behaviours involving pop music choreography. For instance, Larisa's presentation involved references to One Direction[14] and she used their music, whilst Alimah, Cordelia and Layla's performances included a catchy pop song with choreography (see Chapter 5 for an excerpt of Alimah's group presentation). These moments, albeit brief, were important, because this was the first instance when I observed the girls participating in a science-related activity and visibly engaging with science (e.g., presenting facts about the museum object or acting out friction and resistance). As Calabrese Barton et al. (2008) have suggested, meaningful engagement with science can be enabled through 'efforts to merge their [girls'] social worlds with the worlds of school science' (p. 68). I would contend that the instances observed during the class visit provided valuable opportunities where performances of science and hyper-heterofemininity could be successfully hybridised, which contributed to at least momentary shifts in how these girls engaged with science.

While the activity enabled some of the girls the opportunity to engage with science in ways that appeared not to be possible during the science lessons, it made this more problematic for others. The excerpt in Chapter 5 demonstrates that Samira, one of the most science-engaged girls in the study, distanced herself from her classmates' performances. Analysing these data through a gender lens, I suggest that Samira exhibited discomfort with the performances of hyper-heterofemininity. She articulated her experience in the follow-up interview, where she described the

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[14] One Direction is an English-Irish pop music boy band (Source: Wikipedia).

girls in her group as 'really confident and they want everyone to know about them', speculating that they were attracted to 'fame and money', celebrity lifestyles and 'show[ing] each other off'. The below quote suggests that Samira considered science to be in tension with the world of celebrity and entertainment.

> SG: 'What would you say is the main driver for your aspirations [becoming a research scientist]?'
> Samira: 'Interest in science probably, yeah, because it's really, I just think like things from the, like not things to entertain, but actual facts that are like really interesting and fun and you get to do, like, experiments and, like, loads of things that you wouldn't really get to do, if you were a celebrity or if you were like a singer or an actress or something.' (Interview, March 2015)

The promoted ways of doing science in the science museum did not resonate with Samira's ideas of what it was supposed to be about or how she would have to perform in order to engage successfully. The science identity promoted during this activity was not socially available or interesting to Samira, which manifested in her momentary self-exclusion. The broadened ways of doing science in this study appeared to be at odds with the way it was done in the science classroom. Hence, it could have presented a risky endeavour for Samira, who was normally 'winning the game' of school science, to borrow a term from Bourdieu. This finding is interesting, because it highlights that broadened ways of doing science might hinder the opportunities for some people who are successful in engaging with existing/typical practices. This issue has rarely been discussed in the literature (see a discussion of a study carried out by Carlone, 2004 in Chapter 5). While no approach is likely to fit everyone, these findings show the importance of considering possible negative consequences. This has important implications for practice, which I discuss in Chapter 8.

Performances of restrained heterofemininity risking invisibility

In this subsection, I argue that the more restrained versions of heterofemininity appeared to be able to support the girls' engagement with science better, yet they did not necessarily support the level of engagement that teachers would have recognised as strong and authentic. During the science lessons I observed, the girls' performances of restrained heterofemininity consisted of quietness, obedience and the absence of expressions of hyper-heterofemininity that I discussed above. These behaviours gave the impression of (at least) compliant engagement during science lessons, as the following observation notes suggest.

> Sharifa is now writing something in her notebook (there are questions on the slide that they are meant to answer). […] Sharifa is quiet and has not spoken a word to anyone since the start of the class…. Sharifa, who is in the group with Jasmine and two boys, has still not spoken a word. She quietly observes what the others are doing. [Sharifa appears on-task during the lesson, e.g., listening to the teacher's instructions and doing the required work, but barely says a word and never raises her hand or participates in the class discussion unless specifically called by the teacher.] (Observations, NS science lesson, July 2015)
>
> Samira on table 2 does not get involved in the playful shaking of the bag. [This note was taken during a practical activity 'making an ice cream', where most of the class took the opportunity of having more freedom in the lesson to socialise, tease each other, flirt etc. Samira was one of the few students who did not participate in these activities, but remained on task and kept reminding others to do the work they were instructed to do.] (Observations, NS science lesson, November 2014)
>
> Rifat, on table B, is quiet and on task. She takes over the writing for her pair. [Rifat was most of the time quiet and on task and made sure that when working in groups, the work got done.] (Observations, LS science lesson, March 2015)

During the science lessons, the girls' engagement with science was evident in writing down notes, copying text from slides as well as appearing to listen and focus on the teachers' instructions. Similar behaviours were also noted during the class visit to the science museum, although as I argued above, four more girls were observed doing hyper-heterofemininity a substantial amount alongside restrained heterofemininity. The following field notes illustrate examples of the girls engaging with science through performances of restrained heterofemininity during the class visit.

> Aliyah does a lot of 'teacher' work when other students come near them – 'stop running' 'stop taking pictures of other people' etc. […] Samira is walking around

with Ally (science museum educator), who is telling her about some of the objects. Samira does not have a camera to record anything, but is carefully reading labels. [While most other girls are playing hide and seek and running around the gallery.] (Observations, NS class visit, November 2014)

Performances of restrained heterofemininity were particularly common among the girls of South Asian origin; five out of the six South Asian girls in the study predominantly performed these acts (Amna, Asqa, Niya, Rifat and Sharifa). They also represented the majority of all of the girls (5/8) who I categorised as performing restrained heterofemininity. I would suggest that their acts were consistent with 'the dominant stereotype as [South] Asian girls as shy and timid, passive and quiet' (Shain, 2003, p. 77). The girls appeared modest, obedient and hardworking at school. The wider education literature has previously discussed how ethnicity interacts with gender to influence the girls' performances and experiences regarding education (Walkerdine et al., 2001). Focusing on science education specifically, Archer et al. (2012a) have highlighted the importance of the 'interplay between cultural discourses around gender and science in which science is configured as a sexually appropriate' (p. 980), in the case of many girls from South Asian backgrounds.

Previous studies have suggested that performances of restrained heterofemininity (through 'good' behaviours) are important in supporting girls' engagement with science and school in general. From their study of academically successful girls who aspired to studying science and having science-related careers, Archer et al. (2012a) have concluded that 'academic science-aspirant girls in our study all performed sexually "restrained" versions of desirable heterofemininity' (p. 977). While such gender performances supported engagement with science, the authors have warned that those exhibited by some of the South Asian girls in their cohort, in particular the more 'asexual' version of femininity (as viewed from a Western perspective) may at the same time have negative consequences for girls' social acceptability. While the data from this study do not suggest any such tensions, I concur with other researchers that possible challenges might occur as the girls get older (Archer et al., 2012a; Francis, 2009).

The girls' performances of restrained heterofemininity were seen by the teachers in this study as desirable and to some extent even necessary for engagement with science. The link between teachers' expectations of good behaviour and recognition for being engaged with science has been discussed in previous research work. Students who do not behave well risk positioning themselves and being positioned by others as in tension with the normative identities and celebrated subject positions (Brickhouse et al., 2000; Carlone et al., 2014). Brickhouse et al. (2000), who studied science trajectories of science-keen girls from ethnic minority backgrounds, concluded that 'top track science classes were largely reserved for students who were considered well behaved and completed their work on time' (p. 456). In Chapter 5, I discussed behaviour through a Bourdieusian theoretical lens and argued that 'good' behaviour signals students' school 'readiness' to teachers (associated with middle class habitus and capital), who in turn promote students who exhibit such acts. Analysis through a gender lens adds to this by highlighting how the 'good' behaviour appeared to be largely aligned with the girls' performances of restrained heterofemininity.

The data from this study, however, suggest that the girls who predominantly consistently performed versions of restrained heterofemininity risked becoming invisible in the context of the science class. Put another way, doing 'good' behaviour and 'perfect performance' (Carlone et al., 2014) was not sufficient for the girls to be recognised as 'scientific' by their teachers. The teachers spoke about these girls as being 'good' students, yet they did not consider their way of engaging with the subject as authentic. Sharifa, as the observation notes above demonstrated, appeared to be hard working and on task. However, she hardly ever spoke up in her science lessons. Her 'quiet' engagement with science (and the absence of visible/active engagement) had implications for how she was recognised by her teachers. The following quote from a follow-up interview illustrates Mr Cohen's view.

> Mr Cohen: 'Sharifa has been very quiet. She had a great score coming in and she has shown that she is intelligent … she did well in the end of the year course; she

> got a level six. And that's really good for her, she clearly understands the stuff, she takes things in, but she's very quiet. … She is highly able, but I think she is switched off. Either because of the louder students in the class or I don't know. It would be interesting to see her in a lesson with quieter students.' (Interview, July 2015)

Mr Cohen associated Sharifa's quietness in science lessons with being 'switched off', although he also admitted that being seated together with a group of louder students might have played a role in making it difficult for her to speak up. This suggests that Sharifa may have lacked appropriate opportunities to engage with science during the science lessons dominated by loud boys and was therefore, disadvantaged relative to her more confident classmates. I suggest that Mr Cohen's framing of Sharifa's behaviour and participation in the science lessons spoke to the notion of 'playing Fatima's rules' (Aikenhead, 2006). That is, students who are merely complying with classroom norms to perform 'good student' identities might not be recognised as engaging intellectually, which was implied by Mr Cohen's remark.

The teachers' construction of expected and desired student engagement with science appeared to be predicated on a particular model of student behaviour, which girls who performed restrained versions of (quiet, compliant) heterofemininity did not fit. While Sharifa saw herself as 'scientific', her behaviours appeared not to be recognised as such by her teachers. The wider education literature has suggested that passive and unassertive girls risk being positioned as 'pathologised' or 'other', a framing that has been associated in particular with Asian students, the 'deserving poor' and femininity (Archer & Francis, 2007). Walkerdine (1998a) has similarly argued that girls 'often try to be nice, kind, helpful and attractive: precisely the characteristics that teachers publicly hold up as good – asking all children to work quietly and neatly, for example, while privately accusing girls of doing precisely these things' (p. 162). Given that in this study, disruptive behaviour tended to be explicitly reprimanded by the teachers, it is easy to see how obedience and compliance may have appeared as a desirable alternative for students – yet, these were not enough for the girls to be recognised as engaged.

These findings raise concerns about the extent to which students are aware of what performances and ways of engaging with science are expected in the classroom (or as I discussed in Chapter 5, what the 'rules of the game' within a particular field are). I suggest that it is possible that students like Sharifa may not be aware of what celebrated behaviours in the science classroom entail. The expectations of how students are expected to perform in order to be recognised as engaged with science are not necessarily clear or made explicit to them. As Brickhouse (2001) has pointed out, 'a girl who is silent in science class may well be acting in this way because she aspires to be a good girl student' (p. 287). I speculate that Sharifa could have been doing the behaviours and performances that she thought were celebrated within science lessons, with little awareness of how these were read by her teachers. Students who are either not able to decode the assumptions of the 'hidden curriculum' (P. W. Jackson, 1990) or not willing to comply with it, might therefore struggle to succeed in engaging with science in ways that are recognised as 'scientific'.

Muscular intellect and celebrated engagement with science

In order for the girls to be recognised as 'scientific', their engagement with science had to entail performances of muscular intellect (Francis et al., 2010; Redman & Mac an Ghaill, 1997). These performances have been outlined previously in the case of boys to be the dominant performances of science (Archer et al., 2014; Carlone, Webb, et al., 2015) and it has been argued in a project paper that these performances facilitated some girls' engagement with science during a visit to a science museum (Dawson et al., 2016). This study too, found that students were expected to 'claim voice' actively, visibly and confidently during their science lessons. In this subsection, I discuss how performances of muscular intellect were enacted by two highly engaged 'science girls', Dorota and Samira. These two girls mostly performed restrained heterofemininity, yet their performances also included those of muscular intellect, which I contend were crucial for their engagement with science and their recognition (see Figures 6-1 and 6-2). Aside from being high achieving and well behaved 'perfect performers' (Carlone et al., 2014), they were observed being confident and assertive in participating in the classroom and contributing to classroom discussions. In this way, they appeared to be successful in carefully balancing rule-following and rule-challenging. Walkerdine (1998a) has argued that girls need to free themselves from some rule-following in order to gain recognition. The following notes illustrate two instances of Dorota and Samira confidently participating in classroom discussions.

> The usual few students put their hands up – Samira, [three boys] […] [two boys] and Samira keep their hands up most of the time, some shouting out answers. Mr Cohen keeps telling them to put their hands down and give others a chance too. (Observations, NS science lesson, November 2014)
>
> Mr Bramley tells them that scientists would use chromatography to solve the crime – many of the girls nod that they remember doing this last year. Dorota explains to Nicole what chromatography is. (Observation, LH science lesson, June 2015)

Confident and assertive performances appeared to be necessary for enabling a girl like Samira to claim voice in a science class otherwise largely dominated by boys. She was the only girl consistently participating in the science lessons, which were otherwise dominated by a group of five or six loud boys. Her confidence was also evident during a focus group, where she boasted to her male classmate that she was more knowledgeable about science than him.

> [Male name]: 'I drive my teachers crazy, that is how much I know [in science].'
> Samira: 'No, you don't, I know more than you!' (Focus group, November 2014)

Performances of muscular intellect were rare. Exhibiting these acts, however, enabled Dorota and Samira to perform the kind of engagement that was recognised by their teachers' as authentic and legitimate, which was not the case for the girls engaging quietly. To be recognised as authentically engaging with science, the girls had to demonstrate their keenness and scientific knowledge in explicit/visible ways. All the participating teachers agreed that the two girls were the most engaged students in their science classes. Further to their academic achievement, the teachers highlighted their confidence, enthusiasm and active participation during science lessons. Mr Bramley commented that Dorota was 'really enthused' in the science lessons. Mr Bell described Samira as always being 'proactive and doing stuff' and Mr Cohen spoke about her as 'very involved', 'inquisitive' and 'confident' as well as someone who 'will ask questions when she doesn't understand; she'll force explanation that goes beyond'.

Teachers made their recognition of Samira's and Dorota's engagement with science explicit, such as through complimenting the girls in front of the class. Ms Richards, for instance, remarked upon the class's arrival to the science museum that Dorota would be the best student to wear the audio recorder (part of the data collection of this study), because she always 'had a lot of great ideas' and shared them out loud. As I discussed in Chapter 4, Dorota remarked that her teachers often called her 'little Einstein', clearly suggesting her recognition as being 'scientific'. Others have previously argued that explicit recognition is important, because it can contribute to students' sense of belonging and identification with science (Carlone & Johnson, 2007; Institute of Physics, 2012b). The examples from the fieldwork add to the discussion in Chapter 4 about the girls' preliminary engagement with science.

The desirability of confident and visible engagement with science was further evident in the teachers' remarks about the girls who did not display such behaviours. As I discussed above, the 'insufficiency' of performances of restrained heterofemininity was suggested by teachers in the case of Sharifa, whose quietness was read as not being engaged with science. The data about Hayley also illustrates the point that absence of confident and visible performances jeopardised the girls' recognition in the science classroom. Hayley was a science-keen girl who aspired to being a research scientist. Further to her behaviour incurring tensions I discussed above (e.g., Hayley did not always comply to classroom instructions and behaviour expectations), her teachers remarked that she was not very vocal about her interest in and engagement with science. Mr Bramley remarked that Hayley was knowledgeable, but that she was not a sort of student who would 'sing it from the rooftops sort of thing [science]'. Ms Richard, along similar lines, suggested that 'she [Hayley] wasn't passionate about it'. These comments suggest that her performances did not fit with the dominant celebrated performance of engagement with science. As Gresalfi et al. (2009) have noted, recognition in a particular context depends on the ways the members are 'expected, entitled, and obligated to participate' (p. 50). A combination of challenges in terms of the recognition that Hayley encountered at school (as well as at home) appeared to have led her to questioning whether she was, or could be, a 'science person'.

Studies have previously highlighted that being a visible and active participant in school science is neither a possible nor desirable pursuit for many girls to undertake (Archer, Dawson, et al., 2016a). The opportunities for speaking up in classroom are also not equally available to all students (Brown et al., 2005; Lemke, 1990), as Mr Cohen's remark above indicates. The expectation of performances of muscular intellect raises concerns in terms of social desirability and the possibility of incurring social costs (Francis, 2009). Whilst I do not have evidence in my data that this has been an issue for the girls in this study, the findings of previous studies have suggested potential problematic implications of these performances (Archer et al., 2012a). Renold & Allan (2006) have argued that girls might find it difficult to demonstrate their knowledge in the classroom, as such displays of confidence may be seen as overly assertive or 'pushy'. Resultantly, such performances might be read gender 'unintelligible' for girls (Butler, 1999). Gordon (2006) has, similarly, argued that girls who claim physical space in the classroom may have their femininity questioned, as they are traditionally expected to be more still, keep their bodies more contained and their voices quieter. In conclusion, while performances of muscular intellect enabled the two focal girls in this study to be recognised as authentically engaging with science, these performances might be problematic from the perspective of the girls' social positioning and recognition, making it challenging for the girls to negotiate 'doing gender' and 'doing science' within the context of the science class.

6.4 Usefulness of the gender performativity theory for understanding engagement with science

Gender theory has usefully complemented the Bourdieusian theoretical framework that I used in Chapters 4 and 5. Being able to discuss the attributes in relation to the Western gender binary, such as what is 'typically' or symbolically feminine and masculine (Francis, 2000a, 2000b; Francis & Paechter, 2015), enabled a deeper understanding of the girls' preliminary engagement with science. Further, I would argue drawing on performativity theory was useful for examining how gender performances (interacting with other social axes) enabled the girls to engage with science in practice. This approach facilitated the interrogation regarding how different gender performances fostered or constrained the girls' engagement with science, as well as how these performances were recognised by their teachers.

While I did not draw explicitly on the Bourdieu's notion of field in this chapter, in line with my earlier argument that the two theoretical approaches I use in this thesis come from different philosophical traditions and are therefore, best kept separate, I suggest that field could be seen as a useful thinking tool in Butlerian analysis. For instance, the recognition and value of gender performances (and how they support the girls' engagement with science) depended on what was expected within a particular social context. Gender performances that were aligned with the norms and expectations of a particular field supported the production of engagement with science, while those that were in tension made engagement difficult (and risked not being recognised or even reprimanded). In this way, I would contend that the notion of field can be carried across to Butlerian analysis.

6.5 Summary

In this chapter, I have discussed the girls' preliminary engagement with science and their engagement with it in practice during science lessons as well as class visits to the science museums through a gender lens. This has been so as to further unpack the patterns of engagement with science and the influence of the social axes. I argued that despite reproducing seemingly meritocratic discourses that gender did not play a role in who does and chooses science, the girls simultaneously framed some aspects of science as masculine. This was evident through their association of science with cleverness and through links between it and professions that they thought of as better suited to men's interests and attributes than women's. To make it possible to negotiate themselves in science, the girls adopted strategies including reframing 'science people' as nurturing and caring, by challenging the absence of women in scientific progress and by attempting not to see gender difference. These findings contribute to extending the understanding of how girls negotiate their identification with science. Further, I contended that there were limited and narrow ways for how the girls' performances of gender enabled their engagement with science in practice. Performances of hyper-heterofemininity were mostly in tension with doing science and did not enable the girls to engage with it. Performances of restrained heterofemininity appeared to have better supported the girls' engagement with science, yet hard work, obedience and quietness presented the risk of invisibility. To gain recognition, the girls were expected to engage with science through performances that aligned with muscular intellect, by exhibiting active and confident displays of knowledge. While these performances appeared to be successful within the social context of the science class, I questioned whether they presented a risk regarding the gender 'intelligibility'.

Chapter 7: Girls' engagement with science during family visits to the science museums

7.1 Introduction

In Chapters 4, 5 and 6, I focused on the girls' preliminary engagement with science and their engagement with science during science lessons and class visits to the science museums. In this chapter, I examine how the girls engaged with science within the family visits to the science museums. The purpose of this chapter is twofold: first, to examine what opportunities the family visits provided for the girls to engage with science; and second, to analyse and discuss the girls' engagement with science within science lessons as well as during class and family visits. I continue to address my second research question: **How do interactions of gender, social class and ethnicity shape girls' engagement with science within lessons, class visits and family visits to science museums?** I predominantly draw on the data collected through observations of the family visits, which I complement with those from the follow-up interviews with the girls, their parents and one of their teachers, who came to the family weekend. In the second part of the chapter, I also draw on the data from the earlier parts of the study in order to compare and contrast whether and if so how, the girls' engagement with science shifted when they moved between different social contexts and physical settings. To analyse and discuss the data, I draw upon both theoretical lenses I presented in Chapter 2: Bourdieu's theory of social reproduction and Butler's theory of gender performativity.

I begin this chapter by providing a brief overview of the family visits. I discuss family engagement with science and museum objects, the challenges they encountered and the ways in which family members facilitated the girls' engagement with science. I then discuss the girls' engagement with science through a gender performance lens, examining whether a family context enabled different opportunities for gender performances and what implications this had for such engagement. Finally, I discuss how the girls' engagement with science during the family visits related to that during science lessons and class visits to the science museums.

7.2 The family visit experiences, challenges and engagement with science

Reasons to come on the family weekend

The families who participated in this project were not 'typical' science museum visitors and their experiences in such settings were mostly limited. None of the families had visited science museums more than a few times previously and for three families, this was the first time in the particular museum. In fact, two parents from the Longdale High cohort said that they had not been aware that the museum existed prior to receiving the project's invitation. As I argued in Chapter 4, however, the parents' remarks about their limited previous science museum experiences suggested these visits were not necessary organised around engaging with science.

To encourage the families to come to the science museums, they were offered an incentive in a form of travel cost reimbursement and vouchers for food and ticketed activities in the museums (see Chapter 3). When asked about why they decided to come, the parents mostly spoke about wanting to have a fun and social day out (five parents) and see what their daughters were doing at school (three parents). Hayley's mum said that she thought that 'it would have been just a nice day out' and Larisa's mum mentioned that, among other reasons, she had decided to attend 'because Larisa had done a project'. Others have previously found that families often seek to combine fun, social and educational experiences when they visit places like science museums (Borun, 2002). Further to this, the incentives and special provisions also appeared to have played an important role in the families deciding to come. As Larisa articulated, 'it was probably the 4D theatre and the food' that made her family and friends come (they came as a group of eight, with family and friends from abroad). The following quote from Niya's dad illustrates the range of factors that motivated their visit.

> Niya's dad: 'I was thinking [before the visit], it's a good opportunity for her [Niya] to learn and to see the things, you know, with a group and with the help of, you know, a coordinator and the other people there. […] They provided everything, for encouragement of students and families so that they will not feel any hesitation to come there. And even pay for parking […] paid even for the lunch, the snacks.' (Interview, May 2015)

Unpacking the families' motivation to visit is important, because these reasons may have shaped their agendas for the visit and the extent to which they engaged with science, or not. That is, a family that comes to the museum mostly in order to have a day out socialising might have very different experiences and outcomes than one that prioritises learning and engagement with science (Falk & Dierking, 2000). In the case of this study, I suggest that the special provisions were particularly important to consider, because they may have shaped the families' feedback. I reflect on the limitations of this situation in Chapter 8.

Challenges encountered during the family visits

Family experiences appeared to be constrained by a number of challenges they encountered during their visits. These were mostly associated with their not possessing the symbolic linguistic and cultural resources that were required by the science museum in order to access engagement opportunities. Similar issues have been highlighted in previous studies, which have reported on the difficulties of ethnic minority and working class visitors during their visits to science museums and science centres (Archer, Dawson, Seakins, et al., 2016; Ash, 2004; Dawson, 2014b; Rahm, 2008). In this subsection, I focus mostly on two family visits, Niya's and Samira's, that stood out because their parents made attempts to engage, but were disadvantaged by the multiple systemic barriers they encountered. I argue that they were, thus, unable to mobilise their (already limited) science capital.

Not understanding the 'rules of the game' (Bourdieu & Wacquant, 1992) made it difficult for the families to navigate their visit. This was Niya's family's first time in the science museum. Their visit appeared to be ridden with challenges as they tried to figure out what to do, where to go and how to behave (e.g., what was allowed and what was not). For instance, they repeatedly asked me for directions and my input about activities and visit plans, as the following excerpt from the observation notes illustrates.

> They [Niya's family] ask me what to do next and I say whatever they would like. […] As we walk in, the family waits for a minute or two in the lobby. [I think unsure what to do next.] Niya does not seem very confident, so I help out and check with the cashiers what time the next 4D show is (it starts at 15.00). Niya's mum then asks me what they can do in the meantime. I explain to them what is in this building. (Observations, family visit, April 2015)

Regardless of my attempts to position myself as a non-participant observer as much as possible, I became, at times, involved in guiding the family and suggesting exhibits to see and activities they may have wished to do (see Chapter 8 for my reflections about the possible limitation of this dynamic). Consequently, I would suggest that the family saw me as a presumed embodiment of dominant cultural and linguistic capital (Archer, Dawson, Seakins, et al., 2016), thus relying on my input to navigate their visit 'correctly'. Their discomfort was further indicated by their barely saying a word throughout the visit, which was in stark contrast to the lunchtime in the cafeteria that was filled with lively discussions about their home cuisine, what they usually did at weekends and what the children were doing. I interpreted this shift to be an indicator of Niya's family not feeling at ease during their science museum visits. The family also did not take any photos until after their lunch, when Niya's dad asked me if photography was allowed within the museum. They appeared surprised to find out that it was and in the remaining 10 minutes after lunch and before their departure took photos constantly with their phones and the camera that dad had brought along.

Niya's family's visit resonated with previously discussed 'disoriented' family visits (Archer, Dawson, Seakins, et al., 2016). Despite him saying that he was very keen on science (he worked as a nursing assistant and said he had an interest in medical science) and was trying to support Niya with her education, the family was not observed having any science-related conversations during their visit. Previous studies have highlighted how conversations are one of the key indicators of family engagement and a way for families to make meaning and learn (Leinhardt, Crowley, & Knutson, 2002; Leinhardt & Knutson, 2002; Zimmerman et al., 2010). Despite possessing some science capital within the family, it appeared not to be mobilised in supporting engagement with science.

The case of Samira's family's visit further indicated that science capital could only be partially be mobilised in the case of limited possession of symbolic cultural and linguistic capital (see also Chapter 4 for Samira's mum's quote about her general frustration with the lack of multi-lingual resources available in science museums). Samira's mum reported being interested in and knowledgeable about science, saying that they often talked about science at home. While she was to some extent able to engage with the museum objects through leveraging her prior knowledge and experience, I would contend that she was disadvantaged linguistically, as the following excerpt from the observation notes suggests.

> Samira's mum spots a photo of a rocket being launched from a platform in the middle of the sea and calls Samira to see if she knows why they are doing this.
> Samira's mum: 'Look at this, inside the water ... not on the surface. Why?', asking Samira.
> Samira's mum is discouraged quickly from reading the label, but Samar and Samira try to guess what the exhibit is about. They suggest it might be safer this way, as water cannot catch fire.
> Samira's sister: 'Because of the heat, I guess.'
> Samira: 'So that it doesn't spread fire.'
> SG: 'What does your mum think?'
> Samira: 'She doesn't know. She's quite confused.' (Observations, family visit, January 2015)

After showing an initial interest in the object, Samira's mum struggled to understand was it was about. Samira remarked that the difficulty in understanding the exhibit left her mum feeling 'quite confused'. I would argue that language difficulties constrained Samira's mum's engagement with science, because this limited the opportunities to discuss the exhibits and the science behind it. The implications of her poor English were evident throughout the visit, despite some instances of positive engagement.

Being able to engage successfully with science in the science museum required possession of linguistic capital. Language is understood as a form of capital that defines and characterises the value of people and practices as well as playing a powerful role in social exclusion of linguistically non-dominant social groups (Bourdieu, 1991). Others have previously observed that museum visitors are required to understand the language of the institution in order to access the available opportunities (Ash, 2004; Dawson, 2014b). ISLEs in the UK tend to rely on English as the institutional language, which makes it difficult for many non-native English speakers to engage with exhibits and activities (Dawson, 2014b). I would suggest that accordingly, Samira's mum may have encountered what Bourdieu (1998) has denoted as 'the imposition of the dominant [English] language and culture as legitimate' (p. 46). By being unable to participate on equal grounds, she became discouraged and disengaged. As an Arabic and German speaker who emigrated to the UK as an adult, she was clearly from a linguistically non-dominant social group and was, thus, excluded from the dominant sphere of the science museum. Her science capital appeared to have limited exchange value, being constrained by the museum's linguistic capital expectations that did not allow to mobilise her science capital to a fuller extent.

Not understanding the language in the science museum, however, was not only a matter of not speaking and understanding English, but also a matter of scientific literacy. During her family visit, Jasmine on one occasion spent a long time at a particular exhibit, visibly struggling to understand what it said and finally loudly remarked that 'That's not in English!' and moved on. Language used in places like science museums may therefore contribute to exclusion of visitors who have less symbolic science capital than that required to engage with the exhibits. Previous studies have discussed the need for visitors having to be science museum literate and for these literacies to be plural and multifaceted (Archer, Dawson, Seakins, et al., 2016; Bain & Ellenbogen, 2002; Dawson, 2014a, 2014b). My data add to this work by showing through empirical examples that without linguistic and cultural capital, the science capital visitors might possess can only be used to a limited extent.

From a Bourdieusian perspective, poor alignment between the visitors' own habitus and capital (i.e., not knowing the implicit norms of the institution, not possessing the 'right' kind of resources) and the expectations of the field is likely to result in discomfort and feeling out of place. Feeling comfortable and supported in a museum is important and it has been argued that this presents a necessary basis for any successful visit (Rand, 2001; Rennie & Johnston, 2004). Experiences that are ridden with difficulties and those where visitors are particularly disadvantaged by the structure of the institution may contribute to visitors feeling that these places are 'not for them' (Dawson, 2014b). Feeling out of place, as I explained through the examples above, constrained the way families participating in this study engaged with science and resultantly, limited the opportunities for their daughters' engagement with science.

Experiences of family visits and the girls' engagement with science

In this subsection, I discuss how the families were able to engage during their science museum visits and in what ways they supported, or not, their daughters' engagement with science. Table 7-1 briefly outlines the family visits, with an emphasis on the girls' engagement with science and parental facilitation. The intention of this table is not to provide a detailed account of the visits, but rather to present the key features that I unpack further later in this chapter (see also Table 3-4 for details about the family groups and the duration of the visits).

Girls (pseudonyms)	**Brief overview of the family visits – family dynamic and engagement**
Aqsa	Not observed[15]
Cordelia	Mum encouraged Cordelia to be the leader and she took up this role,

[15] This was due to the overlaps of the family visits (see Chapter 3 for more details).

Girls (pseudonyms)	Brief overview of the family visits – family dynamic and engagement
	guided the group around the museum and explained to her family the objects and the science associated with them.
Dorota	Dorota took up a leader role and spent most of the visit teaching and caring for her two younger siblings. Her parents appeared less interested and involved, having few conversations with the children.
Hayley	Not observed
Jasmine	Dad consistently encouraged Jasmine to lead the day and engage with science, but with limited success. She kept rejecting her dad's attempts and expressed annoyance and boredom.
Larisa	No one in the group seemed to be particularly interested. The adults mostly took care of the three young children and Larisa spent most of the visit being quiet and on her own.
Niya	The group appeared disoriented and needing more facilitation than others. Niya barely said a word throughout the visit and appeared disengaged.
Samira	The family seemed confident in navigating their way and interested in the museum objects. Samira and her sister took on the role of translator for their mum. They had several discussions about the museum objects, mostly initiated by the mum.

Table 7-1: Engagement with science during family visits to the science museums

Despite the many challenges that the families encountered, the visits also offered some opportunities for engagement. All of the families were, first of all, observed engaging *socially*, as evident in their chatting (mostly not about science) and having a nice time. All of the families visited the additional activities that they received complimentary tickets for, such as 3D or 4D cinema and had a lengthy lunch. The social aspect was highlighted by the parents in the follow-up interviews as the most memorable part of the visit. Larisa's mum, for instance, remarked that the visit mostly 'brought family together and we had a nice day, had lots of fun and laughs' and Hayley's mum described their visit as 'walking around and chatting and laughing'. Hence, the social aspects appear to have been important during the family visits to the science museums, as previous studies have also reported (Archer, Dawson, Seakins, et al., 2016; Moussouri, 1997, 2003). It has been argued that having a nice social time is a valuable outcome in and of itself and hence, should not be underestimated in terms of its benefits (Birmingham, 2016). Having an enjoyable visit, apart from having a value in its own right, has also been contended as contributing positively to learning experiences (Ellenbogen, 2002; Falk & Dierking, 2000; Packer & Ballantyne, 2004).

The data from this study suggest that positive (social) visit experiences, however, did not necessarily extend to substantive engagement with science. In some cases, the girls even constructed learning and engaging with science as distinct from and in opposition to having fun. For instance, some did not spontaneously relate the two, as the quote from Hayley suggests, 'we learnt about some things [during the family visit], *but* it was more fun'. Similarly, Samira contrasted the 'really, really fun' family visit to having to 'do work' during the previous class visit, thus indicating her preference for the visit that did not involve having to do work. While, as I argued above, having a positive social experience was valuable in itself, it is important to consider to what extent such experiences offered the girls opportunities to engage with science.

The instances that I coded as engagement in this study were notably different from what previous studies on family engagement with science in museums have discussed (see Chapter 3 for an extended discussion on coding in this study). In brief, the families in this study engaged with science in ways that I suggest would have been disregarded by previous studies. These studies, for instance, considered family engagement with science to include substantive conversations involving science content and/or an element of inquiry (Ash, 2003; Zimmerman et al., 2010), which I did not observe during any of the family visits. In the absence of such instances of strong/deep engagement with science, I considered it important to attend to a broader range of activities, behaviours and conversations, including any references to science and science museum objects. As I have argued above by drawing on the work of Nasir & Hand (2008), such instances of relating to the museum objects (even in the absence of more substantial engagement with science) can play a vital role regarding how people negotiate their relationships with a particular domain.

Moments of engagement with science during the family visits mostly included brief family conversations about the museum objects, which they recognised from their everyday lives or were able to relate to their countries of origin. In other words, such moments were enabled through cross-cultural meaning making when parents could draw upon their own personal and cultural resources. Samira's family visit included several such instances. Samira's mum, who was able to mobilise her knowledge and experiences, such as from growing up in Iraq, mostly instigated these. The following excerpt from field notes illustrates how she could leverage her resources in explaining to her daughters about a water pump that she found to be reminiscent of the ones she remembered from her home country.

> Then Samira's mum points at a water pump.
> Samira: 'Yeah, the blue tap.'
> Samira's mum: 'For the water.'
> Samira's mum explains to me and her daughters that their grandfather used to have one of those. Most houses in Iraq would have one, to get water from the ground every day. Samira's mum: 'Before, in my country, when I was small, we didn't have water in every house. Every house, every home had a hole, to get water. Every house! To get fresh water.' (Observations, family visit, January 2015)

I would contend that such cross-cultural making meaning through relating to the objects constituted a valuable example of engaging with science. Another example illustrates how Samira's mum related her cultural knowledge and experience to a science museum object.

> Then they [Samira, her mum and her sister] pass a carpet-weaving machine and mum calls both daughters to come and have a look. She is explaining in Arabic how the weaving machine works [I assume from the hand gestures].
> SG: 'Has she explained to you how it works?'
> Samira nods, says: 'Most people have this kind of job in her country.'
> Samira's mum explains to me that in her country, lots of people make carpets at home. She watched a lot of her neighbours make carpets, although she cannot make carpets herself. (Observations, family visit, January 2015)

Samira's mum was able to draw on her prior knowledge and experience to connect with museum objects. The importance of being able to leverage own resources has been highlighted in previous research work (Archer, Dawson, Seakins, et al., 2016;

Ash, 2003; Dawson, 2014b; Zimmerman & McClain, 2014; Zimmerman et al., 2010). Barriault & Pearson (2010) have argued that '[b]y referring to past experiences, seeking and sharing information, and becoming engaged and involved, a visitor's interaction with an exhibit becomes a meaningful learning experience'. They have regarded such instances as the strongest form of engagement, which they referred to as 'breakthrough behaviours'. Instances where families were able to draw on their prior knowledge, however, were few and limited to science museum objects that had a cultural element that they recognised, which for ethnic minority families were not many. Consequently, this meant that for most of the visit, the families were relatively disengaged and only very seldom stopped at any exhibit, attended to a label or began a conversation.

Making meaningful connections with museum objects, when these did occur, appeared to have played an important role in the girls' impressions of the visit, as reported during the follow-up data collection. For instance, when asked about what she remembered most from the family visit, Asqa recalled cotton machines that related to her dad's childhood in Pakistan.

> Asqa: 'I liked where they built the cotton machines and my dad was telling me about how, in his time, when he was small, there were these types of machines that used to work. And his parents, like my grandparents, they used to know more about this sort of stuff. […] It was in their country, Pakistan.' (Interview, June 2014)

The importance of cultural and personal relevance and being able to make meaning has been widely discussed also in the wider student engagement literature. Lawson & Lawson (2013), for instance, have argued that engagement tends to be enhanced when topics have personal significance to students and when they are able draw upon their prior knowledge and experience.

The girls' own engagement with science was enabled through parental facilitation and through they themselves being able to draw on previously gained resources. Parental facilitation played a particularly important role in the girls' engagement with science, as other ISLE studies have found (Ash, 2003; Crowley, Callanan, Jipson, et al., 2001; Ellenbogen, 2002; Zimmerman et al., 2010). Parental facilitation, however, was rare in this study and did not necessarily lead to the girls' engagement with science. Two parents (Jasmine's dad and Cordelia's mum) actively encouraged their daughters to engage and lead the visit. Jasmine's and Cordelia's families were the most frequent museum visitors among the participating families, which suggests that they possessed more capital that they could leverage during the visit than other families, such as knowing what to do in the museum and how to access the opportunities for engagement.

The active involvement in supporting their daughters was evident in parents asking questions, initiating conversations (e.g., Jasmine's dad asked Jasmine to explain museum objects and science-related phenomena to him) and encouraging their daughters to lead the day. For instance, Cordelia's mum referred to her daughter as the 'leader' throughout the visit and encouraged her to guide the group. Jasmine's dad kept instructing her to write things down and engage in conversations about the museum objects. This, however, was not always taken up by Jasmine, as the following observation notes suggest.

> Jasmine's dad to Jasmine: 'Do you have a pen? This is very important, this part.' Pointing at the information board. Jasmine takes out a pen and starts writing into her notebook.
>
> Jasmine's dad: 'So when you read it, if you want, I can explain a little bit what it is about.'
>
> Jasmine rolls her eyes.
>
> Jasmine's dad: 'Come on, I have to!'
>
> Jasmine: 'Stop talking …' (Observations, family visit, January 2015)

The interaction between Jasmine and her dad during the visit suggests that such conversations may have not been common for them. Jasmine consistently resisted her dad's attempts to engage with the exhibits, e.g., telling him to 'stop talking'.

Further to parental facilitation of the girls' engagement with science, the girls were also observed drawing on the resources that I interpreted as having been acquired during their science lessons and the class visits. For instance, Cordelia told her family group about science that they had recently covered during their lessons and guided them around the parts of science museums that they had previously visited with her school, explaining the objects. The following observation notes from Cordelia’s family demonstrate how she took up a role of an expert, telling her family about what ‘friction’ is and what it does.

> Cordelia explains that it's about how much friction acts on something and that it is 'how easy it is to move’. She appears very confident in explaining this to the rest of the group. (Observations, family visit, April 2015)

The topic of ‘friction’ was one of the foci of the class visit to the science museum, as well as a part of Cordelia’s science curriculum that year. I would, therefore, contend that Cordelia leveraged her ‘school capital’, meaning the resources she had gained at school and school-associated activities, to engage with science during the family visit. The prior school visit thus, served as an opportunity to gain museum-specific cultural capital, which Cordelia was able to use during her family visit.

7.3 Gender performances during the family visits

The girls’ performances of gender during the family visits to the science museum were different from those I observed during the science lessons and the class visits to the science museums. In particular, there were very few instances of what I coded as hyper-heterofemininity and muscular intellect. I argued in Chapter 6 that the performances of the former were often associated with peer popularity (e.g., flirting, chatting and socialising) in that these are often done in a way to gain social status among the peers. During the family visits, these performances were largely absent in the girls’ behaviours. I suggest that the family context offered fewer opportunities for such acts and thus, offered different recognition. As I discussed in Chapter 2, the issues of recognition and acceptance are crucial to how people perform gender (Butler, 1999). I would contend that performances of hyper-heterofemininity and also those pertaining to showing off knowledge (coded as muscular intellect) are less ‘intelligible’ within the social context of the family, which could explain why they were absent from the family visits data.

The family visits provided opportunities for gender performances that were not enacted in the context of the science class. These were, most notably, performances that I coded as nurturing or 'big sister' femininity, closely tied to the family context and sibling relations. These had some similarities with the restrained heterofemininity that I discussed in Chapter 6 (in terms of the absence of expressions of hyper-heterofemininity), but I would argue were specific to the family context. These performances enabled two of the girls (Dorota and Larisa) who visited the science museum with younger siblings, to take on and perform the role of a teacher and carer. Dorota's behaviour was particularly illustrative, whereby she performed 'big sister' femininity throughout the visit. For instance, she spent most of the visit reading museum labels to her two younger siblings, managing their behaviour and helping them to engage with science. The following passage from the observation notes provides an example of this.

> We stop at an exhibit and Dorota shows her sister a light – 'look if you take a white light like that and you put a prism in front of it, the white light splits into lots of rainbows' – she really seems to be keen on facilitating for her little sister and showing her interesting things. […]
> Dorota's brother is moaning and playing up so Dorota takes him by the hand – 'come on let's go and see some more cool stuff. Look in here there's a jacket made of flowers – do you want to see it?' (This is from the school visit). […] Dorota leads her sister over to the dress made from flowers – 'quickly, quickly, come here, come on' – 'do you know what that is, it's a coat made of flowers, is that cool?' 'Feel that fabric, they made that out of this, is that cool?' (Observations, family visit, April 2015)

As is evident from the observation notes, Dorota used science to manage her younger siblings' behaviour and teach them about science. Such instances occurred several times during the visit and Dorota also reflected on her role afterwards.

> SG: 'Did you tell [your family] much about science or the objects when you went to the museum?'
> Dorota: 'Yeah, my brother and sister, I definitely told them a lot about it and sometimes I told my mum about different stuff, but my mum and dad sort of just

> read the stuff themselves and sometimes I would tell them to go and see something, because I found out about it, it was quite cool but it was mainly my brother and sister.' (Interview, June 2015)

Dorota's performances of 'big sister' femininity, however, appeared not to have been elicited by the specific opportunity of the family visit to the science museum. Her mum remarked that Dorota regularly took up a teacher role at home and that she was 'good at explaining things to any children'. Dorota echoed these views, remarking that 'whenever I find cool stuff on the Internet or at school […] I'm always telling them [her parents and her siblings]'. Science appeared to have been co-opted in her performances outside school, i.e., that of being a big sister and a teacher for her younger siblings, which others have found was productive to young people's engagement with the subject (Gonsalves et al., 2013; J. Thompson, 2014). I would argue that the performance of 'big sister' femininity offered a way for the girls to 'do girl' and 'do science' simultaneously. These performances allowed the girls to take up an expert science position *through* femininity, which I did not observe in the context of the science class. There, active and confident participation appeared to have been mostly enacted through performance of muscular intellect, risking being transgressive for girls invested in performing versions of femininity.

From a post-structuralist gender perspective, it is not surprising that gender performances changed when the girls moved from one social context to the next. In the words of Paechter (2003a), 'how we enact masculinities and femininities changes as we move between groups, between places and spaces, and through time' (p. 541). The family visits to the science museums provided a valuable opportunity to compare the girls' performances of gender within the science class and family contexts. Further to the insight this analysis provided for understanding of engagement with science, I suggest that this empirical work also makes a valuable contribution to gender theory with the empirical data on shifting gender performances within different social contexts. That is, while feminist scholarship has acknowledged the role of the context and the constructed nature of gender, this study adds the empirical understanding of how gender performances change from one social context to the next.

7.4 Shifts in the girls' engagement with science

I now examine whether and how the girls' engagement with science shifted between science lessons and science museums visits, focusing on the six girls who attended and were observed during the family visit. I argue that for five of them, engagement with science during the science museum visits did not differ significantly from that within the context of the science class. Three girls (Jasmine, Larisa and Niya), who consistently disengaged from science during the science lessons and the class visits or were only engaging compliantly, the family visits to the science museums appeared not to have offered opportunities that made their engagement stronger. For two girls (Samira and Dorota), who were strongly engaged with science during their lessons as well as more generally, strong engagement with science was to a large extent maintained during the family visit to the science museum. For one girl (Cordelia) who consistently disengaged during school-related activities, the family visit enabled opportunities for stronger engagement with science. In this section, I focus predominantly on the latter girl. I examine what resources she was able to leverage and what this meant for her recognition as a 'science person' by her science teachers and her mum. I discuss Cordelia's engagement with science within science lessons, class visit and family visit to the science museum by drawing on the data from across the dataset to explore what opportunities and challenges shaped her engagement with science.

Cordelia's shift in engagement with science

I categorised Cordelia's preliminary engagement with science as partial-selected; she planned to study science (biology) post-16, aspired to become a midwife, but did not consider herself to be a 'science person'. She held a strong view that many science areas were more suitable for boys than girls. She remarked that her teachers had previously made explicit comments that she was not 'scientific', i.e., that science 'did not like her'. Her teachers also commented on

Cordelia as being 'apathetic' during the science lessons and her mum said that she did not see science as a trajectory that she would expect for Cordelia. During the science lessons, Cordelia often got into trouble for her behaviour, which was often aligned with performances of hyper-heterofemininity. During the class visit to the science museum, Cordelia occasionally engaged with science (such as during the filming activity), but spent a large part of the visit hiding from teachers and socialising with her classmates.

During the family visits, Cordelia exhibited strong engagement with science. She led the day, explained to her family about science and demonstrated hands on activities to them. Cordelia's engagement with science appeared to be supported by her mum's encouragement and by Cordelia's ability to leverage on her previous experience at the class visit (see section 7.2). Her engagement with science during the family visits had implication for how she was recognised by the key adults in her life, such as her mum and her science teachers. They spoke about being surprised about Cordelia's engagement with science during the family visit. Ms Richards mentioned how differently Cordelia behaved in comparison to how she was during science lessons.

> Ms Richards: 'She [Cordelia] doesn't normally take on a leadership role in class. […] She's normally quite happy to sit back and let other people take charge and to do as little work as she can get away with, whereas when she was there, on the day when we all went, but mostly when she was there with her family, she was "I'm going to tell you about the science, let's come over here, I'm going to tell you about this bit, I'm in charge" and I think she understood the science a lot better because she was explaining it to someone else.' (Interview, June 2015)

I interpreted Ms Richards's comment as suggesting a shift towards recognising Cordelia as 'scientific'. For Cordelia, who was marginalised in the classroom, a family visit seemed to have, thus, provided potentially better opportunities for engaging with science, as others have found to be the case for young people from disadvantaged backgrounds who are marginalised in the classroom (Rahm & Ash, 2008).

The argument that some students might be able to engage with science better outside the school setting also resonated with Mr Bramley's views, who suggested that Cordelia might have had a problem with school in general and not with science specifically.

> Mr Bramley: 'There are pupils who don't always correspond to classroom situations […] because in their lives it's all rules and regulations and we've got to do this and we've got to do that and I think it was just the freedom to actually look around [in the science museum] and you know, in a controlled environment, the freedom to be able to just look around and see things and find out things.' (Interview, June 2015)

Despite a relative 'success' of Cordelia's family visit in terms of Cordelia's engagement with science, I suggest that these findings need a careful consideration. Her shift, indeed, hints at a possibility that opportunities outside school might be able to provide more engaging opportunities. It is important to recognise, however, that this was not a typical family visit experience. For instance, Cordelia's mum was specifically encouraged by the science museum staff to support her daughter to lead the day. Therefore, the positive observations in Cordelia's engagement with science should be taken in the light of the extraordinary measures that had been put in place, first, to attract Cordelia's family to the science museum and then, to provide additional support and encouragement during their visit.

It is difficult to say from the available data what longer-term impact Cordelia's experience of the science museum visit may have had. This study did not carry out the delayed follow-up data collection, such as was carried out previously by a few longer-term studies (Calabrese Barton & Tan, 2010; Rahm, 2010). When I asked the participating science teachers about whether they noticed any changes in Cordelia's or any other girls' engagement with science during science lesson, they struggled to point anything out. The teachers' perception of the changes in the girls' engagement with science, however, may have also been due to the their narrow ideas about what engagement with science constitutes and what are the normative ways of doing science within a science lesson (see Chapters 4 and 5). It is also possible that impacts of these visits could only be notable later on. Literature has previously argued that effects of science museums visits often tend not to be immediate, but rather delayed, making them difficult to study (Bamberger & Tal, 2008; Paris, 1997). Nevertheless, I agree with Carlone, Johnson, et al. (2015) that positive opportunities for engagement with science, however minor and brief, may have enabled critical 'cracks' for marginalised young people (like Cordelia) to engage with science and start seeing themselves as possibly 'science-y'.

7.5 Summary

In this chapter, I have examined the girls' engagement with science during family visits to the science museums. I argued that families' overall visit experiences played an important role in the girls' engagement with science. Engagement with science, as conceptualised broadly, occurred when families were able to draw on personal, cultural and science resources. However, the need for multiple co-existing resources meant that several families were disadvantaged culturally, linguistically and structurally. These challenges diminished the potential for engagement. The girls' engagement was aided by parental facilitation and the extent to which they were able to draw on their resources, including school-related capital and experiences from the class visits to the science museums. Performances of gender during the family visits were different in comparison to school settings. Performances of 'big sister' femininity, in particular, opened up opportunities for the girls to take an expert science position through simultaneously 'doing femininity' and 'doing science', which provided a valuable way to engage with science.

A shift in engagement with science within the different social contexts and physical settings was only noted for one of the girls, for whom family visit enabled engagement with science that appeared not to be possible and/or celebrated within the context of the science class. Through family facilitation and encouragement, this girl strongly engaged with science during the family visit. Yet, given the 'special' nature of the science museum visits organised as part of this study, I cautioned that the family visits were far from ordinary. These findings overall suggested that the science museums generally offered limited opportunities for broadening ways of doing science, but offered hints of how engagement with science could be better facilitated and supported for families and young people from lower socioeconomic and ethnically diverse backgrounds.

Chapter 8: Conclusions

8.1 Introduction

In this study, I investigated how interactions of gender, social class and ethnicity shaped engagement with science among 15 secondary school girls from lower socioeconomic and diverse ethnic backgrounds. These girls participated in class and family visits to two science museums in the UK during the academic year 2014-2015. The research aims followed from the concerns that girls/women continue to be underrepresented in many areas of science and that participation inequalities further vary by social class and ethnicity. As I argued in Chapter 1, better opportunities and support for diverse girls to engage with science are, first and foremost, a matter of social equity. Further, higher participation of girls and women in specific areas of science could also address the perceived 'crisis' in science participation and contribute to better and more diverse scientific advances. With formal science education having been critiqued for providing narrow and limited engagement opportunities for diverse students, scholars have turned their attention to the opportunities available outside school. This study contributes to science education and sociology of education scholarship by examining how the interacting social axes shape girls' engagement with science within multiple social contexts and physical settings.

Specifically, I addressed the following two research questions:

1. How do interactions of gender, social class and ethnicity shape girls' preliminary engagement with science?
2. How do interactions of gender, social class and ethnicity shape girls' engagement with science within lessons, class visits and family visits to science museums?

I adopted a qualitative research methodology and collected the data through focus groups, interviews and observations with the girls, their parents and their science teachers. I began analysing the data by mapping out the girls' preliminary engagement with science and their engagement with science in practice. I then interrogated these data through two complementary theoretical lenses, the theory of social reproduction (Bourdieu, 1977b, 1984, 1986) and the theory of gender performativity (Butler, 1993, 1999). In this final chapter, I draw together and discuss the key findings and contributions of this study, reflect on the theoretical approaches I adopted, consider the study's limitations, discuss the implications and make recommendations arising from the findings. I conclude the chapter by suggesting some possible avenues for future research, which might be able to further inform how science education practices can continue to move towards becoming more socially just for all young people.

8.2 Key findings and contributions of this study

This study's contribution to knowledge is a more in-depth understanding of how interactions of social axes shape diverse girls' engagement with science and what role social contexts and physical settings play in supporting or constraining engagement opportunities. In this section, I first synthesise the findings by addressing the two research questions, with an emphasis on the key contributions to knowledge that build on existing research with new insights. I then focus on how the findings of this study contribute to theory by problematising the notion of science capital, conceptualising engagement with science through sociological theory and discussing the contextual nature of engagement with science.

Research question 1: How do interactions of gender, social class and ethnicity shape girls' preliminary engagement with science?

The first research question focused on the girls' preliminary engagement with science, which I conceptualised as consisting of the girls' aspirations and identification with science. The analysis of the data generated five categories: strong, partial-problematic, partial-pragmatic, partial-selected preliminary engagement with science and dis-identification with science (see Table 3-6, p. 103). To unpack the role of interacting social axes, I then discussed the girls' preliminary engagement with science through a Bourdieusian lens in Chapter 4 and through a Butlerian lens in Chapter 6.

Despite egalitarian discourses that science was 'for everyone' and that anyone could do science, the girls' association of some aspects of science with masculinity made it difficult for them to identify with. They made a discursive distinction between difficult and technical 'masculine' science (e.g., engineering, computing and physics) and nurturing and caring 'feminine' science (e.g., jobs that involved taking care of people and animals). By framing some science subjects, topics and professions as masculine, I argued that the girls constructed science as 'unintelligible' for them (Butler, 1999, 2004). The girls further ascribed 'feminine' science-related resources lower value, in some cases even dismissing them as not science, which I suggested highlighted a gendered aspect of science capital. That is, their science-related experiences and knowledge that I interpreted as aligned with traditionally feminine attributes (such as interest in and knowledge of animal care) appeared to have gone under-recognised and hence had limited value in supporting their engagement with science.

The girls who did identify with science used various strategies to resist its dominant discourses as masculine and more 'for boys'. Science education literature has contended that girls and women tend to negotiate their science identities and participation in science through performing femininity in less visible, more 'modest' ways (Archer et al., 2012a; Brickhouse & Potter, 2001) or even through performing acts of masculinity (Danielsson, 2011). The findings of this study contribute to the body of knowledge on girls' identification with science by adding a strategy, whereby the girls constructed 'science people' as nurturing and caring (associating them with caring for the environment, animals and people) and thus symbolically feminine. While this approach was taken only by two of the girls in this study, the finding is important, because it challenges and augments previously outlined discourses. It appears promising that the girls were able to identify with science by constructing 'science people' as more feminine and hence, 'intelligible' for them to perform. I question, however, whether and to what extent this strategy could enable long-term engagement with science. It is also difficult to say to what degree such an approach to identification with science could include *all* science and not exclude the more technical science that tends to be particularly difficult for the girls to identify with, such as highly masculinised areas like physical science.

The role of social class in shaping the girls' preliminary engagement with science was noted in the girls' attitudes towards education (including science education) and their aspirations. Family dispositions, which were internalised by the girls, played an important role in shaping their aspirations towards or against science, as others have also found (Adamuti-Trache & Andres, 2008; Archer et al., 2012b; DeWitt, Osborne, et al., 2011; Gilmartin et al., 2006; Mujtaba & Reiss, 2014; B. Wong, 2012). Families' working class attitudes were evident in the parents' emphasis on letting their daughters develop 'naturally' (Lareau, 2003), while also cautioning them against 'pushing their luck' with regards to higher education (Nash, 1990). Those girls who appeared to have internalised these typically working class dispositions (Bourdieu & Passeron, 1990; Reay, 1998a, 2001a) regarded science, along with progression to higher education, as unthinkable and undesirable for 'people like them'.

This study found, however, that ethnic background and migration history complicated the influence of social class in shaping the girls' preliminary engagement with science. Coming from a working class family did not necessarily result in having typically working class habitus. The girls from some ethnic minority backgrounds, South Asian and Middle Eastern in particular, spoke about high parental aspirations related to science and education, which they internalised as thinkable for them. The girls made explicit links between their aspirations to join 'respectable' science-related professions like medicine and the value and desirability of these professions within their ethnic communities, as other studies have reported to be the case for some ethnic minorities in the UK (Ahmad, 2001; Basit, 2013; Shah et al., 2010). Accordingly, I argued that these girls benefitted from what has been discussed in the literature as ethnic capital, i.e., ethnicity-specific resources that support children's educational and professional aspirations and trajectories (Modood, 2004; Zhou, 2005, 2009). The findings of this study show how ethnic capital operated in the particular area of engagement with science among working class and ethnically diverse girls, thus contributing to the science education scholarship on ethnic minority students (Archer et al., 2012b; DeWitt, Archer, et al., 2011; Elias et al., 2006; Springate et al., 2008; B. Wong, 2016).

An ethnic and migrant background contributed to shaping the girls' habitus, which was responsive and aspirational, rather than reproductive in a Bourdieusian sense (Bourdieu, 1973, 1984; Bourdieu & Passeron, 1990). That is, their habitus did not reflect typically working class aspirations that Bourdieu would have expected them to develop when growing up within a working class family. To the contrary, it was responsive to the situation of social disadvantage, with an aspiration and ambition to improve it. The notion of responsive habitus has parallels with Reay's (2004c) transformative habitus, which she has suggested results from students encountering a field they are not familiar with, such as working class students attending elite higher education institutions. Yet, the responsive and aspirational habitus that I discussed in this thesis was not produced through an encounter with a particular (unfamiliar) field, but rather, through an ambition to improve the existing socioeconomic situation.

The influence of the girls' ethnic background, however, was complex. On the one hand, as I discussed above, ethnicity positively shaped the girls' preliminary engagement with science. On the other hand, their ethnic and migrant background had implications for the exchange value of capital they possessed and were able to mobilise, which in turn constrained their preliminary engagement with science. I thus argued that there was an ethnic aspect to science capital (different from the so-called 'ethnic capital'), in that the exchange value (Skeggs, 2004c) of science capital was complicated by ethnicity and migration (see Carter, 2003; Yosso, 2005). The girls, for instance, spoke about their parents' experiences and knowledge as being of limited value in the UK, because they were not originally from here. The limited amount of science capital they possessed was, therefore, not necessarily mobilised in practice. It appeared, further, that without other forms of capital, such as speaking good English (linguistic capital) and being familiar with the education system (cultural capital), the parents' already low science capital was difficult to leverage in support of their daughters. It emerged that the girls often relied on their siblings and younger relatives for practical support, as other studies have discussed to be typical for some South Asian communities in the UK (Crozier & Davies, 2006; Shah et al., 2010). While valuable, I questioned to what extent such intragenerational capital was able to provide support in terms of, for instance, career advice and provision of educational activities.

The girls' preliminary engagement with science was also influenced by their experiences at school and who they viewed as emblematic of 'science people'; school experiences added another layer to the girls' primary habitus shaped by early socialisation within the family (Bourdieu, 1967). The girls' constructed 'science people' as clever, confident, well behaved and high achieving, similar to what was found in other studies (Carlone et al., 2014; Shanahan & Nieswandt, 2011; Varelas et al., 2011) and considered their own identification with science in relation to these ideas. These attributes have been framed in the literature as being associated with the middle class and masculinity (Archer & Francis, 2007; Francis & Skelton, 2005), hence being difficult to occupy for working class ethnically diverse girls like the participants in this study.

Research question 2: How do interactions of gender, social class and ethnicity shape girls' engagement with science within lessons, class visits and family visits to science museums?

The second research question focused on the girls' engagement with science during the science lessons and class and family visits to the science museums. My data analysis generated four categories: strong, partial-compliant, partial-problematic engagement with science and disengagement from science (see Table 3-7, p. 105). I discussed the girls' engagement with science within the context of the science class (science lessons and class visits) in Chapters 5 and 6 and within the context of the family (family visits) in Chapter 7.

The science lessons appeared to be largely aligned with the notion described in the literature as ‘prototypical science education’ (Carlone et al., 2014; Gonsalves et al., 2013) and offered narrow and limited opportunities for the girls’ to engage with the subject. Performances of (typically working class) hyper-heterofemininity were mostly in tension with science and rarely enabled the girls to engage with it. The behaviours I associated with these acts (e.g., socialising, flirting, singing and focusing on physical appearance) tended to be admonished by the teachers, suggesting that there was an expectation from the students to behave well. The findings of this study also suggested that the girls who were well behaved and did the required work, but who were quiet, risked invisibility in the science classroom. Specifically, performances of what I coded as restrained heterofemininity were excluded from the celebrated positions; these girls’ engagement with science was regarded as merely compliant, lacking authenticity and legitimacy.

Previous studies have found that performances of restrained heterofemininity tend to be more successful for supporting girls’ engagement with science than performances of more sexual heterofemininity (Archer et al., 2012a). The findings of this study, however, resonate more closely with the argument made by Walkerdine (1998a), who has previously opined that girls often face the impossible contradiction of being expected to be passive and obedient, while simultaneously being criticised for it. As I argued in Chapter 6, performances of heterofemininity in this study, both sexual and more restrained ones, sat in tension with engagement with science within the context of the science class, leaving little discursive space for the girls to negotiate ‘doing girl’ and ‘doing science’.

This study found that the way to engage with science that was perceived by the science teachers as authentic, legitimate and celebrated was through performances of muscular intellect, involving confident and active displays of knowledge. These performances were enacted only very occasionally and only by two of the girls in the study, but appeared to be the key to making the girls’ engagement visible and, consequently, recognised by their science teachers. Performances of muscular intellect have been outlined in the literature as typical for middle class boys (Francis et al., 2010; Mac an Ghaill & Redman, 1997). I suggested that such acts might, therefore, present a risk in terms of the girls' gender 'intelligibility' (Butler, 1999, 2004). No tensions were observed during the course of this study, but concerns remain about the longer-term feasibility and social desirability of such transgressive performances, especially as the girls move through teenage years (Francis, 2009).

Following a Bourdieusian analysis, I argued that the context of science class appeared to have privileged middle class 'readiness' for school (Nash, 1990), exemplified in the ways students spoke and participated. The girls whose behaviour was not aligned with the norms and expectations or who attempted to participate and engage with science in ways that were not deemed appropriate by their teachers or their peers encountered challenges in doing so or had their attempts explicitly rejected. Their actions were attributed a negative status, which in some instances led to their withdrawal from the field, resulting in disengagement. Put another way, the girls who did not play by the 'rules of the game' (either seemingly not being aware of them or choosing not to follow them) and those who did not possess symbolic capital to draw upon, struggled to engage with science in the science lessons in ways that were celebrated and supported by the field (Calabrese Barton et al., 2012; Carlone, 2003; Varelas et al., 2011). These findings highlight the important role that social contexts play in supporting or constraining engagement with science. The role of contexts and opportunities was also exemplified by the cases of the girls who rarely engaged with science during their lessons, but who spoke about engaging with science outside the school context.

While science lessons and class visits provided limited opportunities for engagement with science for many of the participating girls, there were valuable moments when the field shifted in a way to open up ways of doing and 'being' in science. During one particular activity on a class visit to the science museum, the girls were encouraged to draw on their creative resources like song writing and dancing to present the science museum objects. They were allowed and encouraged to hybridise science with their non-science interests, skills and values, which provided them with different opportunities to engage with science, including through performances of hyper-heterofemininity (Calabrese Barton et al., 2012). The girls' engagement with science led to their recognition by the science teachers. Even though such moments of engagement were brief, I suggest that they offer an important insight into the possibility that the field can be disrupted in order to enable better engagement with science and contribute to more diverse young people being recognised as 'scientific' (Carlone, Johnson, et al., 2015).

The findings of this study, however, also highlighted that disrupting the normative ways of doing science enabled better engagement with science for some of the girls, but made it more difficult for others. The shift in the field I discussed above appeared to have weakened engagement with science for a student who was successful at it during her lessons, but who seemed not to feel at ease with the broadened/changed ways of doing science. The relationship between habitus, capital, field and practice (see Bourdieu's pseudo-mathematical equation I presented in Chapter 2) provided some explanations (Bourdieu, 1984). This girl's habitus and capital were relatively well aligned during regular science lessons and shifting the field thus disrupted her privileged position, through changing the value and alignment of her capital and habitus. There has been a lot of focus in the literature on how to facilitate (encourage, increase) young people's engagement with science, but little has been done to examine how practices that might open up such engagement for some might inadvertently close it down for others (see Carlone, 2004 for an example of one such study). The findings of this study contribute to filling this gap.

In Chapter 7, I argued that the family visits to the science museums offered different opportunities to school for the girls' engagement with science. For instance, they were able to do so through performances of 'big sister' femininity, which involved teaching and caring for their younger relatives. 'Big sister' femininity, moreover, also enabled the girls to take up an expert position in science, simultaneously 'doing science' and 'doing girl'. The opportunities for engagement with science during the family visits, however, were troubled by the many challenges that the families encountered. In the absence of cultural and linguistic capital, their science capital had little exchange value within the science museum setting. As others have previously found (Archer, Dawson, Seakins, et al., 2016; Bain & Ellenbogen, 2002; Dawson, 2014a, 2014b), there was a need for multiple competencies or literacies within the science museum for the families and the girls to be able to engage with science. Not being able to understand the labels in English and struggling to navigate the space and the rules within it, made it difficult for the families to leverage the little science capital they possessed. While rare moments of engagement did occur, such as when the families were able to draw on their personal and cultural/ethnicity-related resources, the findings suggest that more scaffolding and additional support would be required to enable engagement with science opportunities for the families and consequently, for their daughters.

Next, I discuss the findings that relate to this study's contributions to knowledge beyond addressing the research questions.

Problematising science capital

Science capital refers to science-related cultural and social resources, attitudes and practices that people participate in (see Chapter 2). Previous studies have found that the amount of science capital a young person possesses tends to shape their aspirations, engagement with science and whether they consider science to be 'for them', or not (Archer et al., 2015). This study, too, found that the amount of science capital the girls possessed influenced their identification with science and their aspirations. Whilst the girls in this study all had a relatively low level of science capital, the difference in that which they possessed appeared to be reflected in their preliminary engagement with science. That is, the girls who I categorised as dis-identifying with science possessed the lowest amount of symbolic science capital. In the literature, science capital has largely been discussed in terms of the amount/level that young people and their families possess. Less consideration has been given to the exchange value of different forms and how it interacts with other resources that might support or constrain its deployment. The findings of this study contribute to a more nuanced understanding of science capital, consider the gendered and ethnic aspects and challenge the idea that possessing science capital necessarily means that people are able to benefit from it.

To benefit from any form of capital, it is important that this is recognised and mobilised (Anthias, 2007; Lareau & Horvat, 1999; Skeggs, 2004c). First, the findings of this study suggested that the science capital the girls possessed was not always recognised. For instance, the girls and their parents spoke about resources and experiences that I coded as science-related (e.g., working with chemicals, studying agriculture), but they appeared to not have regarded them in this way. By not recognising the particular resources as science-related, the potential for leveraging these resources was limited. Second, some resources were recognised, but not realised/mobilised in practice. For example, the girls spoke about family members who worked in science-related jobs, such as medicine and engineering, but admitted never talking to them about science or their careers. I contended that such examples could 'count' as a form of science capital if reported by the girls in a survey questionnaire (Archer et al., 2015). In reality, however, their value might have been minimal.

The issues regarding the use and exchange value of capital are particularly pertinent for young people from non-dominant social groups (see Carter, 2003; Yosso, 2005). I argued that there was a gendered and ethnic aspect to science capital. Resources associated with traditionally feminine attributes were, in some cases, under-recognised and disregarded by the girls and hence, not deployed for engagement with science. The exchange value of 'feminine' science capital appeared to be lower than that of 'masculine' science capital. Further, science capital gained outside of the UK had diminished value, particularly in the absence of other resources to facilitate the deployment of this capital (e.g., speaking English, understanding of the education system). This was evident both during the family visits to the science museum and in how parents were able to support their daughters more broadly. These findings further highlight that social contexts critically determine what resources can be used and what exchange value they have.

Conceptualising engagement with science through sociological theory

Through employing sociological theory and drawing on the analysis of empirical data, I operationalised engagement with science as being produced when the girls' capital and habitus were aligned with the field. During the science lessons, for instance, such engagement was produced when the girls' behaviours fitted with the expectations of their science teachers, for this was when their resources were recognised and valued. When habitus and capital were in poor alignment or in tension with the field, engagement was constrained. Examples of such tension included the girls being reprimanded for not speaking science in the 'appropriate' ways, or their resources not being valued. In some cases, the girls withdrew from the field, as Bourdieu (1974) has suggested might happen when students encounter a conflict between their own habitus and the field.

I argued in Chapter 6 that Bourdieu's notion of field carried across to the Butlerian analysis of engagement with science. That is, the findings suggested that engagement was facilitated when the girls' performances aligned with the expectations within a particular social context. Performances of heterofemininity, in this way, were mostly in tension with the teachers' expectations. Performances of muscular intellect, on the other hand, appeared to be better aligned and also enabled girls to 'show off' their science capital. The alignment of the girls' performances with the norms and expectation also influenced whether their engagement with science was denied, challenged or celebrated.

Sociological understanding of engagement with science contributes to science education scholarship. As I argued in Chapter 1, it has been framed in vague and various ways. It has often been focused on the micro-level events and the psychological factors shaping them (R. Azevedo, 2015; Barriault & Pearson, 2010; Sinatra et al., 2015). The approach taken in this study adds a sociological dimension to the notion of engagement with science, which I suggest is particularly valuable for understanding the dis/engagement among young people coming from disadvantaged social backgrounds. It has been widely agreed that engagement and participation in science are not only a matter of being interested in and liking science (Archer, Osborne, et al., 2013). I contend that it matters where young people come from, what values they are socialised with, what resources they possess and what opportunities they are given to engage with science.

Social contexts matter for engagement with science

The social contexts where the girls encountered science played an important role in shaping their engagement with it. Science class, for instance, provided a context where the girls negotiated what science entailed, what it meant to do science and who science was for. The focus of school science on traditionally masculine interests and the privileging of behaviours that aligned most closely with middle class masculinity made it difficult for many of the girls in this study to engage and identify with the subject.

The findings of this study highlighted that engagement with science is shifting and contextual, meaning that it depends on the opportunities that people have. That is, it is made and remade in different ways across time and space. For some of the girls, it was the context of the science class that made it difficult to engage with science. In contrast, their engagement with science was stronger outside the science class, where different 'rules of the game' might have been at play. For instance, two girls in this study consistently disengaged during their science lesson, but reported themselves and were observed engaging much more in their spare time and during the family visit to the science museum. These findings suggest disengagement from science within one context should not be dismissed as disengagement overall.

Finally, this study highlighted the precarious relationship between social contexts and physical settings. This reminder is important, because as the findings have demonstrated, a science class going on a fieldtrip to a science museum is unlikely to enable a change in students' engagement with science unless the relationships between students and teachers as well as the norms and expectations of what is valued are specifically addressed. Bourdieu's notion of field provided a useful way of thinking about the opportunities that the girls had to engage with science in this study. According to him, a field is not about a physical setting, but rather it encompasses a set of relations between the participants, norms, expectations, value and recognition (Bourdieu, 1984; Bourdieu & Wacquant, 1992). It is the lattermost that needs to shift to change the 'game'. I assert that it is possible for the field to shift *within* a particular social context, but this is not easily done (see section 8.5 for recommendations of how this might look in practice). In sum, I stress that it should not be taken for granted that a simple change in a physical setting is in itself able to disrupt the ways of being in science and doing science.

8.3 Reflecting on the theoretical approaches

I now reflect on the theoretical approaches I used to examine the girls' engagement with science in this study. I consider what Bourdieu's theory of social reproduction and Butler's theory of gender performativity were useful for and how the findings of this study challenged these theories. I acknowledge that no single theoretical approach provides tools that can explain every empirical occurrence, but each allow a particular angle of analysis. I discuss some of the theoretical limitations of this study (i.e., what the theoretical approach did not enable me to explain) in section 8.4.

I considered Bourdieu's (1977b, 1984, 1986) conceptual triad of capital, habitus and field to be useful for examining and explaining the reproduction of social inequalities in relation to science, particularly in relation to social class and to an extent, ethnicity nested within social class. Bourdieu's theory provided some explanation for how early socialisation and parental attitudes shaped the girls' habitus and what they considered to be thinkable and desirable for them. His theory of reproduction, however, could only explain the trajectories and aspirations for three of the girls in the study (whose habitus I interpreted to be typically working class). As I discussed above, ethnicity and migration history interacted with social class in such a way that they contributed to the habitus being responsive and aspirational, rather than reproductive (as Bourdieu would argue). This finding challenges the applicability of Bourdieu's theory to migrant and minority ethnic groups. While similar limitations of Bourdieu's work have been noted previously (Modood, 2004; B. Wong, 2016; Zhou, 2005, 2009), this study's findings show how reproductive and aspirational habitus operate in relation to science and across different ethnic backgrounds. Bourdieu's theory was further useful for examining the girls' engagement with science in practice. I argued that such engagement tended to be reproduced when the girls' habitus and capital were in alignment with the field. The field theory also provided an explanation for why a visit to a science museum enabled few additional opportunities for engagement with science, but instead largely reproduced the rules and regularities from the science lessons.

Butler's theory of gender performativity was useful for examining how gender affected the girls' engagement with science. This theoretical lens facilitated examination of why some girls experienced tension when engaging with science and what behaviours were required (and celebrated by the teacher) for the girls to be recognised as engaging with science authentically. By focusing on discursive construction of gender and science, I was able to attend to the nuances of gender performances within different activities. Drawing on post-structuralist feminist work, with reference to examples in the educational and wider literature (Calabrese Barton & Brickhouse, 2006; Dawson et al., 2016; Francis, 2000b, 2005; Francis & Skelton, 2001; Reay, 2001b; Skelton et al., 2010; Walkerdine, 1990; Walkerdine et al., 2001), enabled me to unpack the gendered attributes of the behaviours and discourses. This literature has previously discussed the importance of social contexts for gender performances, which makes some performances more desirable than others (Butler, 1999; Paechter, 2003a, 2003b). This study further contributes with empirical examples to a better understanding of contextual nature of gender performances, by showing the changes in the girls' gender performances between school and family contexts. As I discussed in Chapters 6 and 7, the girls in this study performed gender differently during the family visits to the science museum compared to during science lessons and class visits. That is, performances of hyper-heterofemininity and muscular intellect were barely noticed during the family visits, due to these performances possibly being less acceptable and less relevant in the family context. At the same time, the family visits enabled opportunities for different gender performances, such as ‘big sister’ femininity, which enabled the girls to have different opportunities to engage with science.

Due to their different philosophical underpinnings, I used the two theoretical lenses separately. I considered this to be a more concise and conceptually suitable way to analyse and discuss the data. As I argued in Chapter 6 and earlier in this one, however, Bourdieu’s notion of field could be seen as providing a useful thinking tool also when considering what gender performances were expected and celebrated within a particular context so as to support/constrain the girls’ engagement with science. Others have previously combined Bourdieu’s work with gender theory to examine identities and aspirations (Archer & Francis, 2007). This study contributes to this body of work by showing how combining Bourdieu and Butler’s work can be extended to engagement with science in practice.

8.4 Limitations of this study

In this section, I reflect on the methodological and theoretical limitations of this study. Despite precautions taken and my best efforts to predict and manage any potential problems, some obstacles and limitations were inevitable. The data collection for this study was organised around a series of Enterprising Science project activities, which had its advantages, but also disadvantages. Being nested within a larger project provided me with a valuable opportunity to examine the girls’ engagement with science across multiple social contexts and physical settings. I suspect that without the project support with administration and logistics, it would have been significantly more difficult to organise multiple class and family visits to the science museums. On the other hand, conducting a study as part of a larger project had some limitations. For instance, given the project plan to involve only one class per school meant that the pool of possible participants I could recruit for this study was relatively small. I could not sign up those from other classes in the respective schools, as not everyone participated in the science museum visits. In addition, being tied to a series of project activities meant that I had limited time for participant recruitment at the beginning of the academic year. Northfields School's first parents' evening of the academic year (which I anticipated could be a valuable opportunity to meet parents and recruit them into the study) was scheduled after family weekend at the science museum, meaning that I was only able to recruit the parents through sending home invitations. Consequently, I was not able to recruit as many participants as I had initially planned. However, working with fewer parents meant that I was able to be more flexible and was able to dedicate more time and energy to the participants that I did recruit.

The aim of this study to focus on the girls from diverse ethnic backgrounds led to some limitations in terms of the language, particularly when working with parents. Among the girls I recruited into the study, 10 out of 15 spoke English as an additional language. While the girls themselves were all fluent in English, several of their parents were first generation migrants into the UK and did not speak the language fluently. Prior to the participant recruitment, the teachers from both schools raised concerns about parents' willingness to participate in the study and mentioned that due to poor English, many parents never came into school or attended parents' evenings. I suspect that the combination of not being able to invite the parents to participate in the study personally and their possible lack of English language skills (as well as my lack of fluency in community languages) may have steered some parents away from responding to the invitation to participate. I speculate that the parents who ultimately consented to participate may have possessed more capital, may have been more confident in participating in additional educational activities and spoke better English than those for whom language barriers may have dissuaded them from participating.

Language barriers did not present a limitation only during the recruitment process, but also during the data collection. The challenge was particularly notable during the family visits. For four out of six families observed during their visit to the science museum, English was not the language in which they normally communicated at home. During the visit, these families kept switching back and forth from their mother tongue to English (at least some of the time, it appeared, for my benefit). I speculate that this may have contributed to disruptions of their usual communication. Had I spoken their language, it is possible that I would have observed and recorded different instances of engagement with science. Yet, at the same time, being able to speak in their own language among themselves may have enabled them to have a more authentic visit experience, as they could switch to their own language, if they did not want me to understand what they were saying.

The last methodological limitation I consider is the possible positive bias in some of my data. I anticipate that my presence could have in some way contributed to stronger engagement during the science museum visits. I believe that some of the girls and families may have been more active and engaged, because they were being observed. It has previously been argued that the mere awareness of being observed might make people act in a different (often more active or 'positive') way than normally. This so-called 'Hawthorne effect' (Cook, 1962) may have added to engagement during the science museum visits. Further, the differences between observation notes and the follow-up parents and girls' reflections suggest that the participants might have reported on their visit more positively than it had appeared to be on the day. As I discussed in Chapter 3, families were provided with incentives to come and despite the fact that the day was organised and delivered by the science museum, some of their comments suggested that they associated me with the organisation of the visits. It is possible, therefore, that they wanted to return the favour by rating the experience as highly positive. Niya's case was particularly illustrative of a disjuncture between how the families appeared to have experienced the visit and how they spoke about it afterwards. During the visit, her family barely said a word, struggled to navigate the science museum and I considered their visit to contain very little engagement. Yet, in the follow-up interview, Niya's dad spoke very positively about the visit, including how much they talked and learnt, barely mentioning encountering any challenges or difficulties. During the interview, he also repeatedly thanked me for the visit and for providing the logistical and material support, which I interpreted as possibly playing a role in his complementing feedback about the museum visit. It is equally possible, however, that Niya's family had a more positive and engaging visit than I interpreted from the field notes. As I argued in Chapter 3, engagement is not always easy to observe.

Finally, there were also theoretical limitations in conducting this study, as the selected theories were not able to provide explanations for all the empirical occurrences. This is neither unusual nor unexpected, for as I pointed out above, no single theory can provide explanations for everything. I acknowledge, therefore, that using different theoretical lenses may have led to different interpretations of the data and/or allowed additional issues to surface. Bourdieu's theory, for instance, appeared to have little explanatory power for why some of the girls went 'against the grain' (see my discussion of Dorota's case in Chapter 4). Bourdieu and his proponents have admitted that the theory of social reproduction seeks to provide explanations for the mostly likely patterns and outcomes, but indeed offers little insight in explaining individual actions (Bourdieu, 1993; Nash, 1990).

8.5 Implications and recommendations

As I outlined in the literature discussion in Chapter 1, many previous initiatives appear to have struggled to make any real difference in girls' engagement with science, as evident from science participation patterns stagnating in recent decades. The challenges in relation to achieving greater gender equality are multiple and permeate all levels of education into employment. The frustration about not being able to contribute to change with a simple intervention has been captured eloquently by Valerie Walkerdine, who sought to offer words of wisdom for improving practice, following her study of girls in mathematics.

> We often feel guilty because we cannot simply produce the magic formula – say 'do this' and all the problems will be solved. In many ways, however, our guilt is misplaced. We have argued throughout that there have been too many easy interventions. This does not mean that we should do nothing. Our work has many implications for the classroom, but none of them would solve the problem of women's oppression overnight. We are talking about a political struggle, which takes time and strategy. (Walkerdine, 1998a, p. 160)

The struggle to 'magically' solve the issues of the gender inequalities that permeate our society, however, does not mean that more modest recommendations cannot be made. In this section, I focus on the main implications and recommendations arising from the findings of this study. The implications consider how there could be better support for diverse young people to engage with science. The five key messages concern the following: (i) providing more information about science-related careers and the usefulness and transferability of science skills and knowledge; (ii) acknowledging and explicitly addressing gender inequalities in science; (iii) considering interventions that shift the field; (iv) providing more inclusive informal science learning opportunities; and (v) working more closely with families to support engagement with science.

It is necessary to provide more information about science-related careers and the usefulness and transferability of science skills and knowledge for a broad range of careers in and beyond science. As I discussed in Chapter 4, some of the girls with particularly low science capital appeared to have had very narrow views of what science entailed and had little awareness about the requirements for careers, like medicine or veterinary science. Mostly illustratively, one of the girls commented that becoming a doctor had nothing to do with science and two girls planned to drop science as soon as possible despite also saying that they considered medicine as a secondary aspiration. Better provision of career advice could be achieved through collaboration with science educators and through better as well as earlier provision of career advice to students, which would help them to have a better understanding about what particular jobs entail and what are the requirements for gaining particular qualifications. A recent report by The Gatsby Charitable Foundation (2014) has argued that the UK lags behind other developed countries in terms of the provision of career advice in schools and recommended that increased investment in the career services for all secondary school students are made. Similar calls have been made in other studies and reports (Archer, Osborne, et al., 2013; Reiss & Mujtaba, 2016), further demonstrating the urgency for such actions. Moreover, Moote & Archer (2016) have highlighted the inequalities in careers education provision in England, whereby girls reported receiving less careers education than boys and students from less advantaged backgrounds (i.e., with low cultural capital) claimed that they had received less careers education than their peers from more advantaged backgrounds. These findings suggest that girls like the participants in this study might be particularly disadvantaged in terms of careers education and would benefit greatly from better provision and services.

To tackle the issues of gender inequalities in science, it is important to acknowledge and explicitly address these issues. As I discussed in Chapter 6, the girls considered many areas of science as better suited to boys and were discouraged from considering careers that they regarded to be male-dominated. When they attempted to challenge and resist the dominant discourses of science as being more for boys/masculine, they appeared to have limited knowledge about why this was the case and what progress women have made across various fields of science. I suggested that the girls lacked symbolic science capital, that is, the knowledge and understanding that would help them challenge the dominant discourses of women in science. It might not be sufficient to promote the idea of science being for everyone without addressing the visible issues of gender inequalities in science. I therefore suggest that rather than further promoting a meritocratic idea that anyone can do any science/science-related jobs, science education should consider instead addressing its historical and present gender inequalities (see Sinnes & Løken, 2014). Further, it is important to challenge the dominant ways of doing science (i.e., through muscular intellect), as these might not be necessarily easily performed by girls who desire to perform socially accepted versions of femininity.

The findings of this study suggested that simply taking students to a different physical setting does not in itself foster broader and better opportunities for engagement with science. Even though research on school trips suggests they offer many valuable opportunities to students for cognitive and affective learning (Anderson, Kisiel, & Storksdieck, 2006; DeWitt & Storksdieck, 2008, for an overview), the findings of my study indicated that these opportunities may be more limited than we might like to imagine. In this study, the class visits to the science museums appeared largely to reproduce the norms and practices from science lessons. **To enable a positive shift in engagement science, it is necessary to consider how to challenge the norms and expectations that exist within a particular social context (in order to shift the field).** Only by challenging the normative practices is it possible to create opportunities where diverse young people's resources become more valuable and their behaviours better aligned with expectations. To challenge these, it is not necessary to change a physical setting, for teachers could apply such strategies within the context of the science class. The Enterprising Science project has already applied the approach of shifting the field in practice, i.e., attempting to challenge the norms and expectation of the science class in order to enable more diverse students to engage with science and be valued and recognised as 'scientific' (Archer, Dawson, et al., 2016c; King et al., 2015). This could be done further, for instance, through practitioners reflecting on and challenging the normative practices, such as through considering what students are expected to do as well as whose resources are valued and whose are not.

I discussed in Chapter 7 how visits to the science museums provided limited opportunities for engagement with science for the ethnic minority working class families. Due to linguistic and cultural barriers, the families struggled to navigate their visits. They were limited in the extent to which they were able to deploy their science capital in the absence of other resources. In consequence, I suggest that it is **valuable to provide more inclusive informal science learning opportunities**. Calls for greater inclusivity have been made by scholars and practitioners previously (Dawson, 2014c; Feinstein & Meshoulam, 2014) and the findings of this study emphasise the need for more to be done to address these issues. From the perspective of initiatives, these might have little power to change the institutional structure. Consequently, I suggest that longer-term projects could be considered when working with participants for whom institutions like science museums might present an alien setting. Longer participation would enable visitors to become more comfortable within the setting, which has been argued to be a necessary precondition for any further engagement to take place (Rand, 2001; Rennie & Johnston, 2004).

While possibly helpful to some extent, however, I caution that such longer participation would ultimately ask the ‘excluded’ to get used to the dominant practices, which I consider to be problematic from a social justice perspective. To ensure that informal science learning opportunities become more equitable, these settings need to be radically changed to be more inclusive and supportive to diverse visitors, rather than putting the blame on them for not taking up the opportunities provided (Dawson, 2014b; Dawson, Seakins, Archer, Calabrese Barton, & Dierking, 2015). Professionals working in informal science learning settings could be more reflective about the unwritten rules, prejudice and representation that permeate and constitute them. By doing so, they could begin to shift the field of practice. The findings of this study did not lead to the identification of what sort of specific shifts and changes would work best for these settings to become more inclusive, but they do provide some hints. For instance, as I discussed in Chapter 7, the families engaged with science during their visit when they were able to leverage their personal and cultural resources. I suggest that providing more opportunities for diverse families to do so, along with further scaffolding and support, could be a useful start.

Finally, I propose that **efforts are expended on working with families from disadvantaged backgrounds**. As I discussed in Chapter 4 and as it has been noted by many previous studies (Archer et al., 2012b; Mujtaba & Reiss, 2014; B. Wong, 2016), families play an important role in shaping their children’s aspirations and engagement with science, as well as supporting their longer-term trajectories. The findings from this study indicated that the families’ involvement with their daughters’ science learning and education generally was relatively low. The reasons included parents’ struggles to navigate the educational system in the UK and difficulties with communicating in English. It would be valuable for both schools and ISLEs to consider how to support parents from disadvantaged backgrounds better. Schools could, for instance, consider multi-lingual events aimed at providing parents with information regarding the education system and career options, where these do not yet exist. Further, ISLEs could usefully work more closely with schools and teachers to encourage families to visit, along with ensuring greater inclusivity for diverse visitors on site. Further investigation into what strategies might work best for encouraging families from disadvantaged backgrounds could improve the success of such initiatives.

8.6 Possible directions for further research

By drawing on the findings and implications of this study and the broader science education literature, I now consider three possible directions for further research that I suggest would be particularly valuable in adding to the understanding of how interacting social axes shape diverse young people's engagement with science and how young people from disadvantaged backgrounds could be better supported in engaging with it. Firstly, the findings of this study could be extended to consider other social groups who are underrepresented in post-compulsory science education, such as working class boys from diverse ethnic backgrounds. As I discussed in Chapter 1, Black Caribbean, Bangladeshi and Pakistani boys, along with working class white British boys, appear to be particularly unlikely to continue with science post-16 (Archer et al., 2012b; Elias et al., 2006). Researchers have argued that the way boys negotiate their engagement with science is complex and that the link between science and masculinity is troubled by other factors (Carlone, Webb, et al., 2015). A research question could be adapted from this study: How do interactions of gender, social class and ethnicity shape boys' engagement with science?

Research could, further, be extended to primary school pupils. The majority of science education studies have focused on secondary school and university students. Yet, evidence has suggested that young people's views about who the subject is for appear to be entrenched already by the end of primary school (Archer et al., 2010; Archer, DeWitt, et al., 2013). It would therefore be useful to gain a better understanding of how primary school pupils engage with science, along with how different contexts might be able to provide diverse opportunities for engagement. Research could address questions along the lines of the following: How do interactions of gender, social class and ethnicity shape primary school pupils' engagement with science? How do primary school pupils engage with science in and out of school? How does engagement with science change when young people move from primary to secondary education?

Second, research could be extended to consider the potential of more inclusive practices and how shifting the field between formal and informal settings could contribute to better engagement with science among diverse young people. In the implications section, I pointed out that it would be useful to consider ways to disrupt normative ways of doing science, which could enable more diverse young people to engage with it. Over the past decades, there have been many programmes and initiatives aimed at broadening young people's engagement with science, but these have rarely been accompanied by robust and rigorous research (Phipps, 2008; Wellcome Trust, 2012). It is important to gain a better understanding about whether and how such various approaches might be able to engage diverse young people with science better as well as what impact these might have on their identification and long-term engagement with the subject. Through the Enterprising Science project, we have worked with secondary school science teachers to support them in adopting a science capital teaching approach for their everyday practice (Archer, Dawson, et al., 2016b; King et al., 2015). It could be useful to adopt similar approaches to consider the potential for more inclusive practices in informal settings, including science museums. Research could address questions such as: How can educators/institutions better support engagement with science among diverse and disadvantaged students? What contributes to the shifts in young people's engagement with science?

Third, research could explore young people's engagement with science within a broader range of settings beyond science museums to contribute further insights into what facilitates and constrains such engagement. Examining young people's experiences and engagement within multiple social contexts and physical settings can contribute to a better understanding regarding how engagement with science is produced (Rahm, 2010). The findings of this study indicated that science museums were not ideally inclusive spaces to support diverse families' engagement with science. Extending the focus to other settings, where families might participate in science-related activities, such as at home or in the park, could provide better understanding of the various ways families and young people do science. Such research might also be able to contribute to better understanding of the resources and experiences young people have, but might not be able to draw on at school. In turn, this understanding could inform planning and delivery of future initiatives. Research questions related to this final research direction could include: Where do young people and families from disadvantaged backgrounds experience science? How and why might young people's engagement with science shift within different contexts?

8.7 Final words

This study was aimed at contributing to a better understanding about how interactions of gender, social class and ethnicity shape engagement with science among 15 girls from lower socioeconomic and diverse ethnic backgrounds. I examined how they engaged with science within their lessons, class visits and family visits to the science museums. The findings have highlighted the important role that social contexts, with their norms and expectations, play in facilitating engagement for some, but making it difficult for others. While admittedly small, this study adds new insights to understanding the complexity of diverse girls' engagement with science, with the underpinning desire to contribute to more inclusive science education practices in the future.

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Appendices

Appendix 1: Ethics and recruitment documents

Letter of ethical approval from King's College London

Research Ethics Office
King's College London
Rm 5.2 FWB (Waterloo Bridge Wing)
Stamford Street
London SE1 9NH

12th February 2014
TO: Spela Godec
SUBJECT: Approval of ethics application

Dear Spela,

REP/13/14-1 - Exploring the role of 'race'/ethnicity, class and gender for young people and families' engagement with science through an intervention programme/ Enterprising

I am pleased to inform you that full approval for your project has been granted by the **E&M** Research Ethics Panel. Any specific conditions of approval are laid out at the end of this letter which should be followed in addition to the standard terms and conditions of approval, to be overseen by your Supervisor:

Ethical approval is granted for a period of **three years** from **12th February 2014**. You will not receive a reminder that your approval is about to lapse so it is your responsibility to apply for an extension prior to the project lapsing if you need one (see below for instructions).

You should report any untoward events or unforeseen ethical problems arising from the project to the panel Chairman within a week of the occurrence. Information about the panel may be accessed at: http://www.kcl.ac.uk/innovation/research/support/ethics/committees/sshl/reps/index.aspx

If you wish to change your project or request an extension of approval, please complete the Modification Proforma. A signed hard copy of this should be submitted to the Research Ethics Office, along with an electronic version to crec-lowrisk@kcl.ac.uk. Please be sure to quote your low risk reference number on all correspondence. Details of how to fill a modification request can be found at: http://www.kcl.ac.uk/innovation/research/support/ethics/applications/modifications.aspx

All research should be conducted in accordance with the King's College London *Guidelines on Good Practice in Academic Research* available at:

http://www.kcl.ac.uk/iop/research/office/help/Assets/good20practice20Sept200920FINAL.pdf

If you require signed confirmation of your approval please email crec-lowrisk@kcl.ac.uk indicating why it is required and the address you would like it to be sent to.

Please would you also note that we may, for the purposes of audit, contact you from time to time to ascertain the status of your research.

We wish you every success with this work.

With best wishes

Annah Whyton – Research Support Assistant

On behalf of

E&M REP Reviewer

Information sheet and consent form for students[16]

Invitation to participate in Enterprising Science research study – Information sheet for students

You are invited to take part in this research study. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what it will involve for you. Please take time to read the following information carefully and discuss it with other people if you wish. Please contact us if anything is unclear or if you would like to know more.

Project aims

The project aims to work with young people, their families, teachers and museum educators to:

- Improve teachers' and museum educators' abilities to engage and support *all* students in their learning of science, within and beyond schools.
- Understand how museums together with teachers and families can help increase young people's interest in science and science-related aspirations.

What it entails for you

If you take part you could be involved in some of the following research activities. These activities will happen every year, from when you first take part in the project until December 2017. You do not have to take part in all of them and taking part is up to you.

1. Questionnaire: These will be online, or on paper if you prefer, and will ask you what you think about science in your life, at home and at school. The questionnaire will take approximately 30 minutes to complete.
2. Interviews: You may be asked to be interviewed. Initial interview will last around 45 minutes and additional shorter interviews could be carried out before and after Enterprising Science activities. Interview questions will be about attitudes to school science, participation in science activities and science aspirations. You might also be asked about your expectations and experiences of Enterprising Science activities. We would like to audio record the interviews.

[16] The information sheets and consent forms for students, parents and teachers included here were used to recruit participants into the wider Enterprising Science project as well as my study and therefore, include aspects not addressed in this thesis (e.g., questionnaires, access to students' academic records). The consent forms include the ethics approval numbers for both the Enterprising Science project and this study.

3. Focus groups: You might be involved in up to three focus groups over the course of an academic year, which will last around 30 minutes and will take place at your school. Discussions will focus on your views of science in general, your science activities and your opinions of scientists and science careers. You might also be asked about your expectations and experiences of Enterprising Science activities. We would like to audio record these focus groups.
4. Observations: Up to ten times a year you could be involved in an activity that we are observing, such as a lesson, a museum visit or a family fun day. We may come along to the activities and observe what happens.

Benefits and risks of participation

Your participation is very valuable, as it will help to improve science education for future students. You will be able to benefit from:

- Activity Kits from the [museum name] that will be given to schools involved with this research.
- Access to a range of innovative science learning activities organised by the Enterprising Science project.
- Access to a series of publications throughout the project via the Internet (www.kcl.ac.uk/enterprisingscience); a report about your school that pulls together what the research team found out, at the end of the project, which we can send to you if you ask us via email.

Ethics

Taking part in the project is up to you and if you agree to take part, you will be free to change your mind before data collection begins. In addition, you can withdraw your data from being used, either partially or wholly, up to 2 weeks after data are collected (that is, before our analysis begins), for example after you complete a questionnaire, an interview or an observed activity. You do not need to give a reason, and withdrawing from the project will not disadvantage you in any way. The research is based on an ethics protocol from King’s College London and the British Educational Research Association guidelines.

Confidentiality and Data storage

Focus groups and interviews will be audio recorded and transcribed. All audio recordings will be erased after transcription and all transcripts will be made anonymous. Data with your name on it will not be shown to anyone except the researchers and those appointed by King’s College to monitor the research process, until your name has been taken away from it. Pretend names will be used to describe the people involved in the project and their data when we write or talk about the project in public. Data will be used to make a report for each school in the project, for policy makers/practitioners and for scholarly publications. The raw data will be stored for up to seven years after the end before securely disposed.

What happens next?

We have enclosed a consent form for you to sign and return, should you agree to take part. We have also included a copy of the consent form for you to keep.

Contact details:

Spela Godec Tel: [annonymised] Email: [annonymised]

There is no expected risk to participants. If this study has harmed you in any way, please contact King's College London using the details below for further advice and information.

Supervisor's contact details:

Prof Louise Archer Tel: [annonymised] Email: [annonymised]

Department of Education and Professional Studies, King's College London, Waterloo Bridge Wing, Franklin-Wilkins Building, Waterloo Road, London SE1 9NH, United Kingdom

KING'S COLLEGE LONDON CONSENT FORM: FOR STUDENTS

Please complete and return this form after you have read the information sheet about the research.

Title of study: Enterprising Science

King's College Research Ethics Committee Ref.: REP(EM)/12/13-44, REP/13/14-1

Thank you for considering giving your permission to take part in this research. You should give your permission only if you want to; choosing not to take part will not disadvantage you in any way. If there is anything that is not clear or if you would like more information, please get in touch (contact details are provided on the information sheet).

I understand that I can withdraw from this study at any time by notifying the researchers and without giving any reason. I understand that I will be able to withdraw my data up to two weeks after data have been collected.	
I consent to the processing of my own personal information for the purposes explained in the information sheet. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.	
I consent to taking part in observed activities as part of this research project.	
I consent to taking part in interviews as part of this research project.	
I consent to taking part in focus groups as part of this research project.	
I consent to taking part in questionnaires as part of this research project.	
I understand that confidentiality and anonymity will be maintained and it will not be possible to identify myself in any publications.	
I consent to being audio recorded as part of the specific data collection methods involved in this project, such as interviews, observations or focus groups.	

Participant's statement:

I ____ [insert your full name] agree that the research project named above has been explained to me to my satisfaction, through the information sheet, and I agree to take part.

Student's signature: _____________________ Date: ________________________

Researcher's Statement:

I ____ confirm that I have explained, through the information sheet provided, of the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Researcher's signature: ______________________ Date: _______________________

COPY KING'S COLLEGE LONDON CONSENT FORM: FOR STUDENTS

This consent form is for you to KEEP – permission for you to participate in the research study.

Title of study: Enterprising Science

King's College Research Ethics Committee Ref.: REP(EM)/12/13-44, REP/13/14-1

Thank you for considering giving your permission to take part in this research. You should give your permission only if you want to; choosing not to take part will not disadvantage you in any way. If there is anything that is not clear or if you would like more information, please get in touch (contact details are provided on the information sheet).

- I understand that I can withdraw from this study at any time by notifying the researchers and without giving any reason. I understand that I will be able to withdraw my data up to two weeks after data have been collected.
- I consent to the processing of my own personal information for the purposes explained in the information sheet. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.
- I consent to myself taking part in observed activities as part of this research project.
- I consent to myself taking part in interviews as part of this research project.
- I consent to myself taking part in focus groups as part of this research project.
- I consent to myself taking part in questionnaires as part of this research project.
- I understand that confidentiality and anonymity will be maintained and it will not be possible to identify myself in any publications.
- I consent to myself being audio recorded as part of the specific data collection methods involved in this project, such as interviews, observations or focus groups.

Information sheet and consent form for parents

Invitation to participate in Enterprising Science research study – Information sheet for parents/guardians of students

You and your child are invited to take part in this research study. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what it will involve for you and your child. Please take time to read the following information carefully and discuss it with other people if you wish. Please contact us if anything is unclear or if you would like to know more.

Project aims

The project aims to work with young people, their families, teachers and museum educators to:

- Improve teachers' and museum educators' abilities to engage and support *all* students in their learning of science, within and beyond schools.
- Understand how museums together with teachers and families can help increase young people's interest in science and science-related aspirations.

What it entails for your child

If you give permission for **your child** to take part, they could be involved in some of the following research activities. These activities will happen every year, from when your child first takes part in the project until December 2017. Your child does not have to take part in all of them and taking part is up to you and your child.

1. <u>Questionnaire:</u> These will be online, or on paper if they prefer, and will ask your child what they think about science in their life, at home and at school. The questionnaire will take approximately 30 minutes to complete.
2. <u>Interviews:</u> Your child may be asked to be interviewed. Initial interview will last around 45 minutes and additional shorter interviews could be carried out before and after Enterprising Science activities. Interview questions will be about attitudes to school science, participation in science activities and science aspirations. Your child might also be asked about their expectations and experiences of Enterprising Science activities. We would like to audio record these interviews.
3. <u>Focus groups:</u> Your child might be involved in up to three focus groups over the course of an academic year, which will last around 30 minutes and will take place at your child's school. Discussions will focus on their views of science in general, their science activities and their opinions of scientists and science careers. Your child might also be asked about their expectations and experiences of Enterprising Science activities. We would like to audio record these focus groups.
4. <u>Observations:</u> Up to ten times a year your child could be involved in an activity that we are observing, such as a lesson, a museum visit or a family fun day. We may come along to the activities and observe what happens.

5. Student academic data: To understand how this project affects your child at home and at school, we would like to access the academic data held by the Department of Education, through the National Pupils Database.

What it entails for you

If **you** take part you could be involved in some of the following research activities. These activities will happen every year, from when your child first takes part in the project until December 2017. You do not have to take part in all of them and taking part is up to you.

1. Questionnaire: These will be online, or on paper if you prefer, and will ask you what you think about science in your life, at home and at school. The questionnaire will take approximately 20 minutes to complete.
2. Observations: Up to three times a year you could be involved in an Enterprising Science activity that we are observing, such as a family fun day. We may come along to the activities and observe what happens.
3. Interviews: You may be asked to be interviewed. Initial interview of around 45 minutes and additional shorter interviews could be carried out before and after your participation in Enterprising Science activities. Interview questions will be about your perceptions of science and science careers and your involvement with your child's science education. In addition, you might be asked about your expectations and experiences of these activities. We would talk to you in person at a mutually agreed location, or over the phone, and we would like to audio record these interviews.

Benefits

Your participation is very valuable, as it will contribute to improving science education for future generations. Other benefits include:

- Up to £250 of [museum name] Learning STEM Activity Kits being made available your child's school.
- Access to a range of innovative science learning activities organised by the Enterprising Science project.
- Access to a series of publications throughout the project via the Internet (www.kcl.ac.uk/enterprisingscience); an end of project customised report that contextualises survey data in relation to your school, available on request via email.
- Any travel expenses occurred for the purpose of participating in this research study will be reimbursed.

Ethics, Confidentiality and Data storage

Participation in the project is entirely voluntary and if you both agree to participate, you will be free to withdraw before data collection begins. You may withdraw your family's data, either partially or wholly, up to 2 weeks after data are collected (that is, before analysis begins), for example after you or your child complete a questionnaire, an interview or an observed activity. You do not need to give a reason, and withdrawing from the project will not disadvantage you or your child in any way.

Focus groups and interviews will be audio recorded and transcribed. Part of audio recordings from interviews and focus groups might be transcribed by an external professional, who will sign King's College London confidentiality agreement. All audio recordings will be erased after transcription and all transcripts will be made anonymous. All data collected will be strictly confidential. Pseudonyms will be used for participants in publications arising from the project. The raw data will be securely stored for up to seven years after the end of the project before securely disposed.

The research is subject to an ethics protocol consistent with King's College London and the British Educational Research Association guidelines. All researchers from King's College London have undertaken a recent Disclosure and Barring Service (DBS) check.

What happens next?

We have enclosed two consent forms for you to sign and return, should you agree for your child and yourself to take part. We have also included copies of the consent forms for you to keep.

In consent form 1, we seek for your permission for your child to take part in the research study.

In consent form 2, we seek for your permission for yourself to take part in the research study.

Contact details

Spela Godec Tel: [annonymised] Email: [annonymised]

There is no expected risk to participants. If this study has harmed you in any way, please contact King's College London using the details below for further advice and information.

Supervisor's contact details

Prof Louise Archer Tel: [annonymised] Email: [annonymised]

Department of Education and Professional Studies, King's College London, Waterloo Bridge Wing, Franklin-Wilkins Building, Waterloo Road, London SE1 9NH, United Kingdom

KING'S COLLEGE LONDON CONSENT FORM 1: FOR PARENTS/GUARDIANS

Please complete and return this form after you have read the information sheet about the research. This consent is for your child to participate in the research study.

Title of study: Enterprising Science

King's College Research Ethics Committee Ref.: REP(EM)/12/13-44, REP/13/14-1

Thank you for considering giving permission for your child to take part in this research. You should give your permission only if you want to; choosing not to take part will not disadvantage your child in any way. If there is anything that is not clear or if you would like more information, please get in touch (contact details are provided on the information sheet).

I understand that I can withdraw my child from this study at any time by notifying the researchers and without giving any reason. I understand that I will be able to withdraw his/her data up to two weeks after data have been collected.	
I consent to the processing of my child's personal information for the purposes explained in the information sheet. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.	
I consent to my child taking part in observed activities as part of this research project.	
I consent to my child taking part in interviews as part of this research project.	
I consent to my child taking part in focus groups as part of this research project.	
I consent to my child taking part in questionnaires as part of this research project.	
I understand that confidentiality and anonymity will be maintained and it will not be possible to identify my son/daughter in any publications.	
I consent to my child being audio recorded as part of the specific data collection methods involved in this project, such as interviews, observations or focus groups.	
I agree that the research team may access my son/daughter's academic records for the purposes of this research project.	

Parent/Guardian's statement:

I ____ [insert your full name] agree that the research project named above has been explained to me to my satisfaction through the information sheet and I agree to let my son/daughter:

____ [insert your son/daughter's full name] take part in the study. I have read both the notes written above and the information sheet, and understand what the research study involves.

Parent/Guardian's signature: _________________ Date: _________________

Relationship to Child: Father Mother Guardian Other [Please circle]

Researcher’s Statement:

I ____ confirm that I have explained, through the information sheet provided, of the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Researcher’s signature: ________________ Date: __________________

COPY OF KING'S COLLEGE LONDON CONSENT FORM 1: FOR PARENTS/GUARDIANS

This consent form is for you to KEEP – permission for your child to participate in the research study.

Title of study: Enterprising Science

King's College Research Ethics Committee Ref.: REP(EM)/12/13-44, REP/13/14-1

Thank you for considering giving permission for your child to take part in this research. You should give your permission only if you want to; choosing not to take part will not disadvantage your child in any way. If there is anything that is not clear or if you would like more information, please get in touch (contact details are provided on the information sheet).

- I understand that I can withdraw my child from this study at any time by notifying the researchers and without giving any reason. I understand that I will be able to withdraw his/her data up to two weeks after data have been collected.
- I consent to the processing of my child's personal information for the purposes explained in the information sheet. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.
- I consent to my child taking part in observed activities as part of this research project.
- I consent to my child taking part in interviews as part of this research project.
- I consent to my child taking part in focus groups as part of this research project.
- I consent to my child taking part in questionnaires as part of this research project.
- I understand that confidentiality and anonymity will be maintained and it will not be possible to identify my son/daughter in any publications.
- I consent to my child being audio recorded as part of the specific data collection methods involved in this project, such as interviews, observations or focus groups.
- I agree that the research team may access my son/daughter's academic records for the purposes of this research project.

KING'S COLLEGE LONDON CONSENT FORM 2: FOR PARENTS OR GUARDIANS

Please complete and return this form after you have read the information sheet about the research. This consent is for yourself (parents or guardians) to participate in the research study.

Title of study: Enterprising Science

King's College Research Ethics Committee Ref.: REP(EM)/12/13-44, REP/13/14-1

Thank you for considering giving your permission to take part in this research. You should give your permission only if you want to; choosing not to take part will not disadvantage you or your child in any way. If there is anything that is not clear or if you would like more information, please get in touch (contact details are provided on the information sheet).

I understand that I can withdraw from this study at any time by notifying the researchers and without giving any reason. I understand that I will be able to withdraw our data up to two weeks after data have been collected.	
I consent to the processing of my own personal information for the purposes explained in the information sheet. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.	
I consent to myself taking part in observed activities as part of this research project.	
I consent to myself taking part in interviews as part of this research project.	
I consent to myself taking part in questionnaires as part of this research project.	
I understand that confidentiality and anonymity will be maintained and it will not be possible to identify myself in any publications.	
I consent to myself being audio recorded as part of the specific data collection methods involved in this project, such as interviews, observations or focus groups.	

Participant's statement:

I ____ [insert your full name] agree that the research project named above has been explained to me to my satisfaction, through the information sheet, and I agree to take part.

(Please provide at least one of the following so we can contact you in the future.)

Email address:

____

Preferred contact number:

____

Contact address:

____

Parent/Guardian's signature: ____________________ Date: ___________________

Researcher's Statement:

I ____ confirm that I have explained, through the information sheet provided, of the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Researcher's signature: ____________________ Date: _____________________

COPY OF KING'S COLLEGE LONDON CONSENT FORM 2: FOR PARENTS/GUARDIANS

This consent form is for you to KEEP – permission for yourself (parents or guardians) to participate in the research study.

Title of study: Enterprising Science

King's College Research Ethics Committee Ref.: REP(EM)/12/13-44, REP/13/14-1

Thank you for considering giving your permission to take part in this research. You should give your permission only if you want to; choosing not to take part will not disadvantage you or your child in any way. If there is anything that is not clear or if you would like more information, please get in touch (contact details are provided on the information sheet).

- I understand that I can withdraw from this study at any time by notifying the researchers and without giving any reason. I understand that I will be able to withdraw our data up to two weeks after data have been collected.
- I consent to the processing of my own personal information for the purposes explained in the information sheet. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.
- I consent to myself taking part in observed activities as part of this research project.
- I consent to myself taking part in interviews as part of this research project.
- I consent to myself taking part in questionnaires as part of this research project.
- I understand that confidentiality and anonymity will be maintained and it will not be possible to identify myself in any publications.
- I consent to myself being audio recorded as part of the specific data collection methods involved in this project, such as interviews, observations or focus groups.

Information sheet and consent form for teachers

Invitation to participate in Enterprising Science research study – Information sheet for teachers

You are invited to take part in this research study. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what it will involve for you. Please take time to read the following information carefully and discuss it with other people if you wish. Please contact us if anything is unclear or if you would like to know more.

Project aims

The project aims to work with young people, their families, teachers and museum educators to:

- Improve teachers' and museum educators' abilities to engage and support *all* students in their learning of science, within and beyond schools.
- Understand how museums together with teachers and families can help increase young people's interest in science and science-related aspirations.

What it entails for you

If you take part, you could be involved in some of the following research activities. These activities will happen every year, from when you first take part in the project until December 2017. You do not have to take part in all of them and taking part is up to you.

1. <u>Observations:</u> Over the course of an academic year, you could be observed during your regular science lessons and Enterprising Science activities, at school and at the museum. We may come along to the activities and observe what happens.
2. <u>Interviews:</u> You might be asked to be interviewed. Initial interview will last around 45 minutes and additional shorter interviews could be carried out before and after Enterprising Science activities. We might ask to interview you every year that you are involved with the Enterprising Science. Interview questions will be about your experiences teaching science, science activities inside and outside classroom, and differences between students and their science engagement. Interviews will take place at school. With your permission, we will audio record these interviews.

Benefits

Your participation is very valuable, as it will contribute to improving science education for future generations. Other benefits include:

- Up to £250 of [museum name] Learning STEM Activity Kits being made available your school.

- Access to a range of innovative science learning activities organised by the Enterprising Science project.
- Access to a series of publications throughout the project via the internet (www.kcl.ac.uk/enterprisingscience); an end of project customised report that contextualises survey data in relation to your school, available on request via email.

Ethics, Confidentiality and Data storage

Participation in the project is entirely voluntary and if you agree to participate, you will be free to withdraw before data collection begins. You may withdraw your data, either partially or wholly, up to 2 weeks after data are collected (that is, before analysis begins), for example after you complete an interview or an observed activity. You do not need to give a reason, and withdrawing from the project will not disadvantage you in any way.

Interviews will be audio recorded and transcribed. Part of audio recordings from interviews might be transcribed by an external professional, who will sign King's College London confidentiality agreement. All audio recordings will be erased after transcription and all transcripts will be made anonymous. All data collected will be strictly confidential. Pseudonyms will be used for participants in publications arising from the project. The raw data will be securely stored for up to seven years after the end of the project before securely disposed.

The research is subject to an ethics protocol consistent with King's College London and the British Educational Research Association guidelines. All researchers from King's College London have undertaken a recent Disclosure and Barring Service (DBS) check.

What happens next?

We have enclosed a consent form for you to <u>sign and return</u>, should you agree to take part. We have also included a copy of the consent form for you to keep.

Contact details:

Spela Godec Tel: [annonymised] Email: [annonymised]

There is no expected risk to participants. If this study has harmed you in any way, please contact King's College London using the details below for further advice and information.

Supervisor's contact details:

Prof Louise Archer Tel: [annonymised] Email: [annonymised]

Department of Education and Professional Studies, King's College London, Waterloo Bridge Wing, Franklin-Wilkins Building, Waterloo Road, London SE1 9NH, United Kingdom

KING'S COLLEGE LONDON CONSENT FORM: FOR TEACHERS

Please complete and return this form after you have read the information sheet about the research.

Title of study: Enterprising Science

King's College Research Ethics Committee Ref.: REP(EM)/12/13-44, REP/13/14-1

Thank you for considering giving your permission to take part in this research. You should give your permission only if you want to; choosing not to take part will not disadvantage you in any way. If there is anything that is not clear or if you would like more information, please get in touch (contact details are provided on the information sheet).

I understand that I can withdraw from this study at any time by notifying the researchers and without giving any reason. I understand that I will be able to withdraw my data up to two weeks after data have been collected.	
I consent to the processing of my own personal information for the purposes explained in the information sheet. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.	
I consent to taking part in observed activities as part of this research project.	
I consent to taking part in interviews as part of this research project.	
I understand that confidentiality and anonymity will be maintained and it will not be possible to identify myself in any publications.	
I consent to being audio recorded as part of the specific data collection methods involved in this project, such as interviews and observations.	

Participant's statement:

I ____ [insert your full name] agree that the research project named above has been explained to me to my satisfaction, through the information sheet, and I agree to take part.

Email address:

____

Teacher's signature: _________________________ Date: _______________________

Researcher's Statement:

I ____ confirm that I have explained, through the information sheet provided, of the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Researcher's signature: ______________________ Date: ________________________

COPY KING'S COLLEGE LONDON CONSENT FORM: FOR TEACHERS

This consent form is for you to KEEP – permission for you to participate in the research study.

Title of study: Enterprising Science

King's College Research Ethics Committee Ref.: REP(EM)/12/13-44, REP/13/14-1

Thank you for considering giving your permission to take part in this research. You should give your permission only if you want to; choosing not to take part will not disadvantage you in any way. If there is anything that is not clear or if you would like more information, please get in touch (contact details are provided on the information sheet).

- I understand that I can withdraw from this study at any time by notifying the researchers and without giving any reason. I understand that I will be able to withdraw my data up to two weeks after data have been collected.
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- I consent to myself taking part in observed activities as part of this research project.
- I consent to myself taking part in interviews as part of this research project.
- I understand that confidentiality and anonymity will be maintained and it will not be possible to identify myself in any publications.
- I consent to myself being audio recorded as part of the specific data collection methods involved in this project, such as interviews or observations.

Leaflet for parents about the project

Summary about the project for parents

About the project

Enterprising Science project is a five-year partnership between the [museum name], King's College London and BP, bringing together research and experience in science learning.

We are working in collaboration with the following science museums across the UK:

- [names of museums - anonymised]

Project aims

The project aims to help students find science more engaging and useful for improving their opportunities in life. This will be achieved by developing creative approaches for working with young people and their families in and out of school.

What does taking part entail for you?

We hope that taking part will be fun!

Young people and families who take part will have an opportunity to participate a range of activities, such as going to the museum. We would also like to ask you a few questions to find out what you thought of the activities and you think your child is doing at school.

If required, we would be happy to arrange translators.

We are looking forward to meeting you!

For more information, please visit: www.kcl.ac.uk/enterprisingscience

Appendix 2: Examples of project resources

Example of object engagement card [omitted]

Object presentation plan

This plan was distributed to students during the pre-visit science lesson, to help them prepare the presentations they would later film during in the science museum.

[redacted]

Object presentation plan

You are going to plan how you will communicate what you know about your object to your friends. In the museum you will use this plan to create a 30 second film clip about the object.

Pick a presentation style

Interview * poem * news report * song * demonstration * voice over * role-play.

The style of my presentation will be...

Hook their attention

What fun and quirky opening line will make your friends want to discover more?

Explain the science

How does the object link to the science you have learnt about in school?

How will you communicate this in a fun way?

Link it to everyday life

Can you link it to something that your friends and family already know about?

E.g. tell a personal story that brings it to life.

I think you'll be interested to know…

Ask a 'wonder' question

Think of a question that will get your audience talking and thinking.
E.g. *I wonder why…*
I wonder how…
I wonder what it would be like if…

I wonder…

Use this space to write a script or draw a storyboard for your presentation

Appendix 3: Data collection schedules

Below are the focus group, interview and observation schedules that I used to collect data with participants. These are final combined schedules for collecting data for the study presented in this thesis and the Enterprising Science project (see Chapter 3). Probes and prompts are included in brackets.

Initial student focus group schedule

Introduction

Welcome and introduce focus group, e.g., I would like to ask you a few questions about your views on science and science related activities.

Ask participants to say their name and age.

Views on science

1. What do you think of when I say ‘science’? (areas of science, interesting/boring/scientists, like/dislikes about science in general)
2. What about school science?
3. Do you like science lessons?
4. What’s good/not so good about science lessons? (What generally happens in science lessons; how does science compare to other subjects?)
5. What do you find most interesting in science lessons?
6. What are your teachers like? (likes/dislikes)
7. To what extent is science you learn at school useful in your everyday life?

Science identity and aspirations

8. What kinds of people do/like science? Who would you think is a ‘science person’? (Are you?)
9. What sort of person do you imagine to be a scientist? (clever, hardworking, imaginative, geeky)
10. Do you think science is more for boys than girls?
11. Do any of you want to a science career? (What do you want to do in the future?)
12. Do you think it is important to know about science? Why/why not?

Science outside the classroom

13. What kinds of science-related activities do you do outside school? (zoo, museum, doing experiments)
14. Who do you talk to about science? (help with science homework; parents, friends, siblings)
15. What kind of other activities do you usually do with your families, e.g., during the summer, at weekends?

Role of family (class, ethnicity, gender)

16. Do you know what your parents think about science? Do they think it is important? Do they encourage you to do science?
17. Does anyone in your family work in science/science-related job?
18. What kind of expectations do your parents have of you? What would they like you to be in the future? Why? Does anyone you know do this job?
19. Do your parents expect the same from your brothers or sisters?

Thank students for taking part in the focus group.

Initial parent interview schedule

Introduction

Welcome and introduce the interview, e.g., I would like to ask you some questions about your views on science, and about how [child's name] is doing at school...

ABOUT PARENT: Views and experiences in science

1. What do you think about when I say the word 'science'? (likes/dislikes, images, areas of interest)
2. To what extent would you say you personally are interested in science, or not?
3. Did you like school science? Did you consider it to be important?
4. What is your level of education? Did you go to school in the UK?
5. Do you use science in any way in your work? (In what way? Do you enjoy it? Was this what you studied? Have you ever worked in a job that involved science?)
6. What kind of work do you do?
7. Do you know friends and family who work in science? If so, in what kinds of ways? (medicine, engineering)
8. What do your friends and family think about science?

ABOUT CHILD: Engagement with school/with science inside school

9. How is your child getting on at school? Are there any challenges?
10. How does your child get on with other pupils?
11. How is your child getting on in science at school?
12. How does s/he enjoy science at school? (likes/dislikes, problems, interests, attainment, teachers)
13. Does your child like their science teachers? What are they like?

ABOUT CHILD: Science their child's future

14. Does your child have any ideas about what he/she wants to do in the future? (jobs, careers, interests)
15. And what sorts of jobs do you think would suit you child/what would you like to see your child doing? Do you have any particular expectations?
16. Do you know what your child would need to know to achieve this?
17. What do you think about you child becoming a scientist? (What about your other children, can you see that happening? Why/why not?)

ABOUT CHILD: Gender, class, ethnicity

18. Some people say that it might be more difficult for some students than others to pursue a career in science – and that science is mostly for white and middle class males? What are your thoughts on this?
19. Do other parents have similar expectations of their children to yours?
20. Are there typical jobs people from similar backgrounds to your aspire to?
21. Do you have similar expectations of your sons and daughters?

ABOUT CHILD: Engagement with science outside school

22. How involved would you say you are with your children's schooling? (homework, other activities; Do you go to school often?)
23. Does your child talk to you about school science?
24. What kinds of activities do your children like to do?
25. What kinds of activities do you tend to do as a family, e.g., during the summer, at weekends?
26. Do you do any science related activities in your spare time? (museums, botanic gardens, parks, city farms, gardening, cooking and watching science-related TV).
27. Have you ever bought your child a science toy/science game/experiment set?
28. Have you been to the [museum name] before? (What was it like/why not?)

Thank parent for taking part in the interview.

Initial teacher interview schedule

Introduction - about school and science teaching

1. How long have you been a teacher? How did you end up in a current position?
2. How do you think students in this school are getting on in science?
3. What do you think are the challenges facing science teachers?
4. Have you seen any changes over the years?

Science students (gender, ethnicity, class)

5. What sort of students tends to do well in science? (behaviour, quiet, clever, active, those who do homework?)
6. Is there a particular group that tends to do better?
7. How do boys and girls generally do in science?
8. Are you aware of any gender differences in terms of their interest, engagement, or how well they do in science? How different or similar are the boys and girls in general in your lessons?
9. From your experience, how do ethnic minority students generally do in science?
10. Women, people from working class background and people from some ethnic minority groups are underrepresented in science course at University and in science careers. Do you have any thoughts about this?
11. Do you know any students that went on to study science at university, or became a scientist?
12. Can you imagine any student here that might end up taking a science career route? Why?

Science outside the classroom

13. Do you ever participate with your class in science-related activities outside of school? (trips to museum, zoo, parks)
14. How beneficial do you find this for students' engagement with science?
15. Do you see any differences in how students experience these activities?

Role of family

16. How important do you think it is for parents to engage with students' schoolwork? (Do those students do better, what are parents' abilities to help?)
17. Do you ever encourage homework that actively includes parents?
18. How important do you think parents' interest/knowledge of science are for students' engagement with science?

19. Do you have any idea about the expectations parents have regarding what they hope their children will do in the future? (families from different background, boys-girls, ethnic groups)

Thank teacher for taking part in the interview.

Observation schedule – science lessons

Record what happens every 5 minutes.

Science lesson

- Activities during the lesson
- Topic
- Structure
- Any connections to everyday lives/careers/wider context?

Students' behaviour and participation

- What are students doing?
- Are they on task/off task?
- Students' participation in the lesson (asking questions, doing their tasks)
- Interactions between students, group interactions
- Does anything stand out?
- Engagement, disengagement

Getting to know students

- Students who stand out (confidence, interest, knowledge)?
- Are there different groups of students sitting together?

Observation schedule – class visit to the science museum

Record what happens every 5 minutes.

Logistics

- Time, location, type of activity, who is involved
- Starting and ending conditions

Outline of what happened during the activity

- Participation in activities
- Role of teachers and museum staff
- Questions or comments made by students (including interactions with teachers/assistants, museum staff, other groups)
- What sorts of social interactions were taking place during the session?
- Range of engagement, disengagement – who is on/off task and how often?
- Anything stands out as unusual?
- Pattern/flow of the activities (Were there parts that went faster, louder, slower, seemed more or less exciting?)
- Did activities change over at the right times, did some take longer than others?
- What participants' responses were to the different elements of the *activity*

Reflections after the event

- Anything that stood out on further reflection (Were certain students seemed more involved than others? Were teachers more/less involved than at school?)

Observation schedule – family visit to the science museum

Record what happens every 5 minutes.

Logistics

- Date, time of arrival/departure, time spent in different parts of museum
- Entry/start conditions (How was the day introduced, were instructions given and by who, how were the activities introduced?)
- Any noteworthy contextual conditions (Was the day particularly busy, hot, wet, was the taxi/bus late, did the families get shown to room, logistical issues that arose?)
- Number of participants and breakdown of participants (which members of family attended, how many teachers, museum staff)
- Exit/finish conditions (How was the day or activity brought to a close, any logistical issues at the end? How did participants leave? Was taxi/bus on time?)

Outline of what happened during the activity

- What were each member doing, looking and talking about?
- Questions or comments made by participants (including museum staff, teachers, family members as well as students)
- What role(s) did the museum staff play?
- What role(s) did parents and other family members play?
- What role(s) did teachers (if present) play?
- What sorts of social interactions were taking place during the session?
- Note range of engagement – who is on/off task and how often?
- Anything that stood out as unusual?
- Degree to which participants used 'trail' and explored other things. References to class trip, class work, homework and other lessons.
- Any difference in the dynamic between parents and sons/daughters?
- Any reference to their culture?
- Are students in any ways different than in class/school trip to museum?

Reflections after the event

- Anything that stood out on further reflection (Were certain students more involved than others?)

Follow-up student focus group schedule

Ask participants to say their name and age.

Recent activity – classroom sessions

1. You and your class did some activities in class which were developed by the [museum name], what do you remember about those?
2. What were those lessons about?
3. What do you think the purpose or aims of those lessons were?
4. Was there anything you liked about the activities?
5. Was there anything you disliked about the activities?
6. Did you learn anything in particular from it?
   Probe if not mentioned: space and forces
7. Did everyone in the class/group feel the same about it, or not?
8. How were the activities different from your usual science classes?
9. What would you change about the activities if you could?
10. Would you want another similar programme of activities?
11. Did the activities make you think differently about anything?
12. Did anything surprise you?
13. Did you talk about it afterwards or not? (Who? friends, family?) What was memorable about it?

Recent activity – class visit to the science museum

14. You also visited the [museum name] with your class, what do you remember about that trip?
15. Was it the first time you had been to [museum name]?
16. What were the activities about during that day?
17. What do you think the aims of those activities were?
18. Was there anything you liked about that trip?
19. Was there anything you disliked about that trip? (likes/dislikes in relation to different galleries and topics?)
20. Did you learn anything in particular from your trip?
21. Did everyone in the class/group feel the same about it, or not?
22. Did anything surprise you? Did the visit make you see science in a different way?
23. Did you feel that any of the topics or objects were preferred by different students, e.g., boys or girls?
24. What did you think of the groups you worked with? Were there any problems?

25. Did you talk about it afterwards or not? (Who? Friends, family?) What was memorable about it?

Thank students for taking part in the focus group.

Follow-up student interview schedule

[Could skip part of the interview if spoken to them before.]

Background

1. (For students who came on the family visit.) To get a better idea of you and your family's visit to the museum, could you describe your family to me? (Probe: who lives in your home? Who do you spend most time with? What sorts of things do you usually do together?)

Reflection on the family visit

2. You visited the [museum name] recently, what was it like? (What did you get from it? What do you remember doing while you were there? Use specific prompts from the field notes.)
3. Who wanted to go on the trip? What made you and your family come on the family visit?
4. Have you talked about the visit with your family since? What sorts of things did you talk about? Did you go back? Why/why not?
5. We know from research that places like the [museum name] are often seen as places for posh, white people – what do you think about that? (What did you think when you were there?)
6. How does the [museum name] compare to other things you do as a family or other places you visit? (cinema/zoo) What about the kinds of people who were there? What about the kinds of activities there?
7. Did you use anything you had learnt during your class trip to the [museum name] while you were there with your family? (Did going on the class visit make you feel more or less excited/confident/nervous about going with your family?)
8. What do you think you got from the visit, if anything? (fun day out, opportunity to spend time together, learning about science)
9. Were there any parts of the visit that you particularly liked, disliked/didn't like so much?
10. What did you learn while you were at the [museum name]?
11. What about the other people in your group?
12. How was a trip with family different from the trip with your school?

Change and the future

13. If you were in charge of organising the visits, what would you do differently?
14. Was there anything in particular you think would have helped you and your family get more from your visit?
15. Is there anywhere else you would like to visit? Why?

16. Is there anything you think we should know to help families like yours make the most of visits to the [museum name]?
17. And is there anything else you would like to talk about on these topics?

If the girl did not take part in the initial or follow-up student focus groups, refer to the relevant schedules to ask additional questions.

Further questions to consider

18. What do you think about girls becoming scientists?
19. Was the museum visit with family different from when you went with school? In what way?
20. Do you see science in any ways differently after going to the science museum?

Thank student for taking part in the interview.

Follow-up parent interview schedule

[Could skip part of the interview if spoken to them before.]

Views and experiences of the visit to the science museum

1. You visited the [museum name] [just over a week ago/two weeks ago], what was it like? What did you get from it? What do you remember doing while you were there?
2. Why did you decide to go to the museum? (learning)
3. Have you talked about the visit with your family since? What sorts of things did you talk about?
4. Were there any parts of the visit that you particularly liked?
5. Were there any parts of the visit that you particularly disliked/didn't like so much?
6. What do you think [student's name] got from the visit, if anything?
7. What about the other people in your group?
8. In your opinion, did you and your family get what you wanted from the visit? [Prompt: in what way]

We're interested in what would make a visit to the [museum name] better for you and families like yours …

9. If you were in charge of organising the visits, what would you do differently?
10. Was there anything in particular you think would have helped you and your family get more from your visit?
11. What do you think about going back for another visit, do you think that's something you might do as a family? (What would need to be different for you to be more likely to visit [museum name] again?)
12. Is there anything you think we should know to help families like yours make the most of visits to the [museum name]?

Now, I'd like to move on by asking you a bit about [student's name] and science at school and then about your views on science more generally – this helps us get a better overall picture of the families who have visited. Don't worry – this isn't a quiz!

ABOUT CHILD: Engagement with school/with science inside school

13. How is your child getting on at school? Are there any challenges?
14. How does your child get on with other pupils?
15. How is your child getting on in science at school?

16. How does s/he enjoy science at school? (likes/dislikes, problems, interests, attainment, teachers)
17. Does your child like their science teachers? What are they like?

ABOUT CHILD: Science their child's future

18. Does your child have any ideas about what he/she wants to do in the future? (jobs, careers, interests)
19. And what sorts of jobs do you think would suit you child/ what would you like to see your child doing? Do you have any particular expectations?
20. Do you know what your child would need to know to achieve this?
21. What do you think about you child becoming a scientist? (What about your other children, can you see that happening? Why/why not?)

ABOUT CHILD: Gender, class, ethnicity

22. Some people say that it might be more difficult for some students than others to pursue a career in science – and that science is mostly for white and middle class males? What are your thoughts on this?
23. Do other parents have similar expectations of their children to yours?
24. Are there typical jobs people from similar backgrounds to your aspire to?
25. Do you have similar expectations of your sons and daughters?

ABOUT CHILD: Engagement with science outside school

26. How involved would you say you are with your children's schooling? (homework, other activities; Do you go to school often?)
27. Does your child talk to you about school science?
28. What kinds of activities do your children like to do?
29. What kinds of activities do you tend to do as a family, e.g., during the summer, at weekends?
30. Do you do any science related activities in your spare time? (museums, botanic gardens, parks, city farms, gardening, cooking and watching science-related TV).
31. Have you ever bought your child a science toy/science game/experiment set?
32. Have you been to the [museum name] before? (What was it like/why not?)

ABOUT PARENT: Views and experiences in science

33. What do you think about when I say the word 'science'? (likes/dislikes, images, areas of interest)
34. To what extent would you say you personally are interested in science, or not?
35. Did you like school science? Did you consider it to be important?

36. What is your level of education? Did you go to school in the UK?
37. Do you use science in any way in your work? (In what way? Do you enjoy it? Was this what you studied? Have you ever worked in a job that involved science?)
38. What kind of work do you do?
39. Do you know friends and family who work in science? If so, in what kinds of ways? (medicine, engineering)
40. What do your friends and family think about science?

Before I go, could I ask you a few more quick questions about yourself for the research project?

41. How old are you?
42. How would you describe your ethnic background (read list from parental science survey page 2 if you need to and probe ethnicity breakdown as per questionnaire if needed, e.g., when you say 'Asian' could you be more specific?)
43. Is English your first language?
44. How many children do you have?
45. How many children aged 17 or under live in your house?
46. Do you consider yourself a single parent?
47. What's your highest level of education?
48. What's your partner's highest level of education?
49. Would you mind telling me whether you are currently working?
50. Would mind telling me what it is you do as a job?
51. Would you mind telling me about whether your partner works/ what they do for a living?
52. What's your highest science and/or maths qualification?
53. What's your partner's highest science and/or maths qualification?

Is there anything else you would like to talk about on these topics?

Well, thanks very much for taking the time to talk to me. It's really helpful for us to get an insight into what you think about these issues. We'll be working with [school name] for the next few years, so we'll probably be in touch through the school about the next steps of the project once term starts again.

Follow-up teacher interview schedule

Views and experiences of the school visit

1. You and your class recently visited the [museum name]; can you tell me your view on how that went? (likes/dislikes, specific details if mentioned, e.g., what worked/did not work, who engaged and who did not and why)
2. How do you feel that the students reacted to the visit?
3. What do you think worked well?
4. What do you think did not work so well?
5. What would you change about the visit, if anything, and why?
6. To what extent did the visit fit with your existing teaching plan and/or the curriculum? (extent to which visit was natural fit and enhancing lessons or is a ‘bolt on’)
7. How much extra work/ preparation did the visit require from you? (Worth it? Too much/too little?)
8. Did you feel that the visit built and followed on from the activities in the pre-visit lessons? (What worked well, not so well? What would you change?)
9. Do you take your students on many trips out of the classroom to places like museums?
10. How did the visit compare to the kinds of things you have done before on school trips? (topic, format)
11. What did you get out of taking part in the visit? What could have been better? Lost opportunities?
12. What do you think your students got out of taking part in the activity? (Ask about different students) What could have been better? Missed opportunities?

Go through each student:

13. Did you put the students in groups they were with a particular goal in mind?
14. Differences between girls and boys during the museum visit?
15. How do they get on in science? Any noticeable changes since the start of the year? Has anything surprised you in the museum; did anyone got more or less involved that you would expect?
16. Did your students talk about the visit afterwards, or not? (What were the most memorable/forgettable elements?)
17. Views and experiences of visit to [museum name] – family visit
18. Some students from your class recently visited the [museum name] with their families … from what you heard about can you tell me your view on how that went?
19. Did your students talk about the visit afterwards, or not? (What were the most memorable/forgettable elements?)

20. What do you think your students got out of taking part in the activity? And their families? (Ask about different students) What could have been better? Missed opportunities?

Other questions to follow up from the previous data collection.

Thank teacher for taking part in the interview.

Appendix 4: Overview of the data collection

	Girls (pseudonyms)	Initial focus group	Initial parent interview	Class visit to the science museum (attended)	Family visit to the science museum (attended)	Follow-up focus group	Follow-up student interview	Follow-up parent interview
Northfields School	Alimah	✓	✓	✓		✓	✓	
	Aliyah	✓		✓		✓	✓	
	Caitlin	✓	✓	✓		✓	✓	
	Jasmine	✓	✓	✓	✓	✓	✓	✓
	Samira	✓	✓	✓	✓	✓	✓	
	Sharifa	✓		✓		✓	✓	
Longdale High	Amna			✓		✓	✓	
	Asqa	✓		✓	✓		✓	✓
	Cordelia	✓		✓	✓		✓	✓
	Dorota			✓	✓		✓	✓
	Hayley				✓		✓	✓
	Larisa	✓		✓	✓		✓	✓
	Layla			✓		✓		
	Niya			✓	✓		✓	✓
	Rifat	✓		✓		✓	✓	

Appendix 5: Examples of the data: Transcripts and field notes

Below are examples of the data I collected.

Transcript (excerpt) of the follow-up student focus group with Alimah, Aliyah, Caitlin, Jasmine and Samira

26th February 2015
Science faculty common room, Northfields School

[…]

SG: Do you remember after you had the lessons about the museum visit, did you speak to anyone about it, like friends or your parents?

Caitlin: I spoke to my parents about it, because we took so many selfies.

SG: But that was after the museum. OK, we're getting now to the museum visit, so when you went to the [museum name] with your school, was this the first time for any of you to be in the [museum name]?

Caitlin: No, every year in primary.

All: No

SG: You went before as well.

Samira: Twice.

SG: You all went before.

F: We went to the Natural History Museum.

Alimah: I like it more now, because I like the people more than primary.

SG: Yeah, so you've all been before. Do any of you think that visit was any different from the visits you've been to before?

Caitlin: Yeah, actually, because it's changed a bit.

Alimah: Yeah, because of the people, they're more fun.

SG: You like your classmates…

Jasmine: Well, not really. The only difference I would say is like the people, that's it.

Few: Yeah.

SG: And do you remember activities or places where you went to during the day?

Samira: The presentation.

Caitlin: Launchpad.

SG: Presentation, Launchpad, what else do you remember about going to the [museum name] with school?

Jasmine: I loved the Launchpad, it was really good, because there was this one where you had to go inside this place and then there was, it was a spinney thing, so you stood on it and you like held your hands like that and you have to [inaudible 0:12:11] like that and then you would like spin yourself. It was like ice skaters, the way you spin, it was like really fast.

Caitlin: Oh yeah, that thing…

SG: Was that the one when you sort of hold something and you kind of go around?

Jasmine: Yeah, you hold into the middle and then you spin round. I loved it and I used to put my hand out and smack… [Laughs].

SG: What else do you remember about your visit to the [museum name]?

Samira: Presentation, the show.

SG: The show, what did you think about the show?

Jasmine: It was good.

Samira: It made me deaf.

SG: Do you remember any science from any of the museum places?

Alimah: Force and gravity in the workshop.

Aliyah: They got this rocket, I think it was and I think they put it on like, they got the rocket, I don't know what rocket it was but it was a rocket and they lit it.

SG: Was that a part of the show?

Aliyah: Yeah.

SG: And what do you think were the aims of the activities that you were asked to do there?

Samira: The presentation.

Alimah: We were given that little notebook thing.

SG: Yeah, what did you think about the notebook, did you write much in it?

Caitlin: No.

Alimah: No.

Aliyah: Yeah, after the trip, yeah. [Laughter].

SG: You wrote something in it after the trip, Aliyah, yeah?

Aliyah: Yeah.

SG: What about the others, did you write much in it?

Alimah: Mine got taken off by my English teacher…

SG: Your notebook got taken away, Alimah?

Alimah: Because I was drawing in it in class, so it was taken off me and then I got it like a week ago.

SG: Did you write something during the trip?

Samira: No.

SG: No?

Jasmine: I think I did write on Saturday [on the family visit].

Jasmine: I was doing my shopping.

Caitlin: I think I did write something.

SG: You wrote something in it on the Saturday for your shopping?

Jasmine: Yeah. [laughter]

Alimah: But Miss, I wasn’t in when they got the photos and the stickers so I didn’t get them. Oh, I did put it in the back of my planner with the…

Jasmine: I've still got the photos, the stickers in my planner.

SG: Yeah, some of the students came with their families a couple of weeks ago.

Alimah: She said I took photos on the camera, but I didn’t get them.

SG: So, what were the things you liked most about the trip?

Caitlin: We played the a lot.

Alimah: Me, Sharifa and [male name], we played ‘it’.

SG: You played what?

Alimah: ‘It’.

SG: It, at the museum?

Jasmine: Yes, the bit, I don’t know what bit, launch.

SG: What did you like about the museum, if we move on?

Alimah: I really wanted to learn something about the BT tower and I did.

SG: OK.

Caitlin: What did you learn?

Alimah: I can't remember. [Laughter]. It was a long time.

Jasmine: I liked, I'm not sure if it was a part of it, but you know when you enter the [museum name], there's a big thing with these…

SG: Sort of a big circle and…

Jasmine: Yeah, I really liked that, it looked really nice. I enjoyed looking at that and reading it, it was good.

SG: Yeah, anything else you…?

Aliyah: The activities we’d done.

SG: Yeah, which one did you like best, Aliyah?

Aliyah: I liked, it was near the [gallery name] and yeah, it was just like fun, like with the magnets and that thing you had to spin.

Caitlin: One thing in the [gallery name] made me scared, man, when you have to like thingy that thing and then it pops.

SG: The one that’s really, really loud?

Caitlin: Like thingy that thing and then it pops.

SG: Yeah.

Jasmine: I remember the helium, the balloon. I've done that at home over a candle, it shocked me, I was like …

Jasmine: And the music.

Alimah: Yeah.

SG: Which music, the one you put the straw in your teeth?

Samira: Yeah, it just vibrates and it’s cold.

Jasmine: I remember that, it was cool, like you could hear it from your mouth, I'm like…

SG: Do you remember reading any of the labels to see what sort of science is behind it, or was it more playing?

Jasmine: I think it was from the vibration, so the vibration from your teeth went up to your ears, it was like…

SG: Yeah.

Jasmine: So you bite on it and…

SG: Yeah, because it's all connected, you can hear it even though…

Jasmine: Because all your senses are connected.

SG: And what were the things that you didn't like so much about the school trip to the [museum name]?

Caitlin: The groups.

SG: The groups, you didn't like the groups. The same, Samira, you didn't like the groups?

Samira: Yeah.

SG: Were there other things?

Alimah: I didn't like keep looking at things, it was boring. It was long, long, OK, it was so long, like it took up, half the wall up and they even had to make a hole in the ceiling for it to fit, the black and white one.

SG: Was that this one [showing an image of the object]?

Alimah: Yes. [Laughter].

Caitlin: That was my object, yeah. But it was so annoying, when you're trying to take a photo but you can't actually fit all of it in the camera, so you had to take two photos and stick them together. Not mentioning any names, but yeah, I didn't like it.

Jasmine: You know when you had to like, when you were filming your thing, when you didn't get to move around really, you had to stay in that one particular area…

Alimah: All you could do was just show it like that.

Jasmine: Yeah and it was like kind of really boring, because our team finished.

SG: Why couldn't you move?

Jasmine: Because you had to stay in that area.

Caitlin: Like in the camera space.

SG: Was there you didn't like so much, Aliyah, any galleries or any topics?

Aliyah: No.

SG: Do you think it was more of a topic for boys?

Aliyah: No, not the boys.

Alimah: Kind of.

Samira: What was?

Caitlin: A bit, just a little.

Aliyah: Wait, what was?

SG: Your topic was space and forces.

Alimah: Oh yeah, that was…

Samira: Pace or space?

Jasmine: Boring, apart from the…

SG: Space.

Jasmine: When was that, when did we do that?

Aliyah: Don’t you remember?

Caitlin: The first subject was space…

Alimah: When we took the photos?

SG: Did you like the topic, did you think the topic was interesting?

Samira: I'm not interested in physics, but is physics like stars and space?

SG: It includes that as well, yes.

Aliyah: I learnt more from primary, because we just learnt about it there.

Caitlin: Every time we went to the [museum name] in primary, we were learning about new subjects, we were learning about new things, so it’s [inaudible 0:19:37] and I hated my group back then as well.

SG: Do you think anyone in your class was particularly interested in the objects?

Aliyah: [male name].

SG: [male name] and [male name], yeah?

F: Yeah.

SG: [male name].

Caitlin: Every time he kept pointing at everything, taking photos of so much.

Alimah: Aliyah was, I know that.

Aliyah: Yeah.

Jasmine: I do think other people enjoyed it as well, because it was a fun time, but maybe some people didn’t like it.

SG: So you were just mentioning a few boys that really enjoyed it, can you think of any of the girls that did?

Alimah: Sharifa did and Aliyah.

SG: Yeah, Aliyah, do you agree?

Samira: I did enjoy it.

SG: Yeah, you enjoyed it.

Alimah: I didn’t enjoy it.

SG: Not so much?

Aliyah: I enjoyed it.

Alimah: I did actually enjoy …

Samira: I liked the activity stuff but not the looking.

SG: Not the objects so much?

Caitlin Yeah, we took selfies.

Alimah: There was too much paparazzi though.

Aliyah: Paparazzi?

Caitlin: Yeah.

Jasmine: You mean tourists?

SG: What do you remember taking pictures of, was it the objects more or selfies?

Alimah: Ourselves.

Aliyah: That’s you guys, I took pictures of the models.

Samira: Obviously!

Caitlin: Then why do I have so many selfies on my phone where you took my phone, where you tried taking selfies of yourself?

Aliyah: No, I didn’t.

SG: Was that both on your phones and the cameras that we gave you? Did you show anyone the pictures that you took, your families or your friends?

Jasmine: I didn’t get to, because I didn’t have my phone. Do you want to see it?

SG: No, I'm just interested if you showed it to anyone.

Aliyah: I didn’t think we were allowed our phones.

Caitlin: Yeah, we were allowed our phones.

Alimah: I was, I could get hold of my phone.

Caitlin: I took so many selfies on my phone.

SG: Did you talk to anyone after the visit?

Jasmine: My mum and dad.

Caitlin: My dad.

Samira: My mum.

Jasmine: My dad just brought the subject out of me, I was like …

SG: After the school visit?

Caitlin: There's only my mum …

SG: Yeah, do you remember what you talked about it?

Few: No.

Caitlin: My mum was like, first thing my mum said was did you take any selfies, that’s the first thing my mum said, she's like, did you take any selfies?

SG: What did you say?

Aliyah: My mum wasn’t really interested.

Alimah: My dad asked me, ‘did you learn anything’? That was his first question.

SG: What did you say, Alimah?

Alimah: I said, yes, a bit.

SG: What did you tell him you learnt, do you remember?

Alimah: I told him about that thing. [Laughs].

Aliyah: What is that thing?

Alimah: The model I had.

Caitlin: It’s so obsessive to me, why. That was the model that [inaudible 0:22:31].

Alimah: I loved that one.

F: This one.

Caitlin: The thing that I actually liked after we did it was watching everybody's videos. [Laughs].

[…]

SG: Did you see anything or did anything that was surprising, anything you didn't do before when you went to the [museum name]?

Few: Yeah.

SG: What was that, Alimah?

Alimah: I was running around.

Jasmine: You are so hyper.

Alimah: Yeah, I know.

Jasmine: I was running around all those [inaudible 0:24:45] of the whole thing, I was just running around on those white stairs chasing people and playing hide and seek.

SG: So you were playing lots of games there, is that what you remember?

Alimah: I just can't forget the games bit, that was so fun.

SG: Alright, and just before we finish, is there anything else you want to let me know that was either really good or not so good about the museum, what could be better?

Samira: No writing in notebooks and having to do work.

SG: So you want to just wander around?

Samira: Yeah, I don't think that we should always, the notebook thing was.

Aliyah: That's the whole point of being at a museum.

SG: What do others think?

Aliyah: Well, to record stuff.

Samira: Have fun and to take selfies and to run around the place.

Caitlin: That's my type of museum.

SG: What was that, Caitlin, what would make this trip better for you?

Caitlin: What would make the trip better is if we didn't have to write anything, we didn't have to look at stuff that we did not want to look at and choose our own groups, oh my God.

SG: Is there anything that would make it better for you Jasmine?

Jasmine: I agree with Caitlin, like writing stuff down, it might not have been like that ideal for us, because sometimes we just wanted to look at the different stuff and just walk around instead of stay with one object and write something about it.

[…]

Transcript of the follow-up student interview with Dorota

16th June 2015
Empty classroom, Longdale High

SG: For the start, can you just say your name and how old you are?

Dorota: My name is Dorota, should I say my second name as well?

SG: No, that's fine.

Dorota: Alright and I'm 13.

SG: Well, what do you remember about the school trip?

Dorota: I don't know, in my other trips we sort of only focussed on going to one area of the museum and learning about one specific part, whereas in this one, we got to look throughout the whole museum. Not necessarily the whole museums, there were parts we didn't all get to see, but we got to go to different areas of it, learn about different stuff, rather than just learning about the textiles industry. We learnt about other stuff as well, yeah, basically and machines and all that, so yeah, that's how it was different.

SG: Was there anything you particularly liked about the school trip?

Dorota: Well, I liked it, because we sort of got to explore, instead of having to stay with the teachers and look around different areas. We were able to partner up and look around, take photos, that sort of stuff, you know, learn about different stuff the way we wanted to, rather than having the teachers, having to follow the teachers around and learn what they wanted to tell us.

SG: Did you feel you had more freedom?

Dorota: Yeah.

SG: And was that a nice change?

Dorota: Yeah, it was. I got to sort of, not necessarily do what I wanted, but I got to look at the stuff I wanted to see and learn about the stuff I wanted to learn about, rather than just focussing on one subject that the teacher told me I had to focus on, sort of thing, so yeah, there was more freedom like that.

SG: Cool, and was there any part that you disliked, didn't like so much?

Dorota: No, I kind of liked all of it, I especially liked the bit where they had the presentation and we were all able to go up and take part and all that. So I liked that bit, but I don't think there was anything that I disliked.

SG: Do you like the performing side of things?

Dorota: Yeah.

SG: Are you involved in performing anywhere else?

Dorota: Yeah, performance arts and all that, yeah, music, I'm involved in that a lot and drama, so yeah.

SG: And when you went to the museum with your family, remind me, you went with your mum and…?

Dorota: Yeah, my mum and my dad and my younger brother and sister.

SG: Was it the first time for any of them to be at [museum name]?

Dorota: Yeah, it was the first time for all, well, my brother kept saying that he went there on a school trip as well, but my mum kept saying that she can't really remember him going on a school trip. So I don't know. It was either the first time for all of them or the first time for my mum, dad and sister, but not the first time for my brother, I don't know, one or the other.

SG: What was the visit like?

Dorota: It was fun, being able to talk to my family about it and my brother and sister really enjoyed it. We got to see some of the different parts of the museum that I never got to see before, because on the other trips there were still restrictions. We still had to stay in certain areas and now we could go anywhere we wanted and we even went to the 3D cinema, which I really liked and my brother was petrified when he got out. But my sister was, there was this one really disgusting sort of bit, where there was a dinosaur and water splashed on our faces to sort of like give an effect and my sister was like proper freaked out by iy. And she loved it, but then at the end she was like, I'm going to need to have a bath when I get home, because she thought it was all real.

I loved the cinema, even though if it was just a show, like it was still cool and some of the other areas of it. I don't know, that I didn't get to see before. There was this part where, the scientific area where they had lots of different experiments, different things you could do. There was one area where if you went on the back and you started riding it, there was a little skeleton next to you and it did the exact same thing as you. So you could like see what your body looks like on the inside. There was another part that tested your reaction time and another part that was showing you how fibre optic stuff works. And you know, there were lots of different experiments in this one little area and I really liked that part.

SG: And who wanted to go on the trip, whose idea was it, mostly?

Dorota: Mine, yeah, I told my mum about it and she thought it would be quite a cool idea, so yeah.

SG: And what do you think made your family come on the visit?

Dorota: I don't know, I think it was probably mostly because I sort of would not stop talking about it until my mum actually said yeah. But we, as a family, we always like to go out and go to different places every weekend and that sort of stuff. So I think it's that whole sort of adventure inside of us that wanted to go, yeah, that made us want to go there and see it all, because we never saw that museum before.

SG: OK, what sort of other things do you tend to do at the weekends?

Dorota: Well, Sundays we don't do much, mainly because of church and all that, because of our religion. But Saturdays, we always have something planned. If it's nice and sunny, we might go to a different park every Saturday, we've been to lots of different parks. Sometimes we sort of just have little barbecues outside in our garden, if we can't think of anything else to do and we invite family over. Once we sort of went swimming, other days we actually went to a zoo, even though we only went there for about two hours or something, we didn't get to explore the whole thing, it was still fun and there's always an activity in the park, like there's that hot air balloon that was like this week. We're going to go there this week and every time there's a funfair, we always go there. We went there for my sister's birthday, when [female name] and [female name] were there, so she got to see them. I don't know, it's anything that's close to us and fun and new, that we haven't done before, we always go there. Maybe climbing or something like that.

SG: Cool and did you talk much with your family about the visit since you went, do you remember?

Dorota: Well, yeah, for about the first two weeks and all that, my mum was always calling everyone, just like, 'you have to see this museum' and she was talking about how scared my brother and sister were of the cinema and all that, but how it was still really cool. I was talking to, when I got to school, I was talking to most of my friends about it. They only really cared about the free food that we got, but yeah, some of them found it quite cool and then after that it kind of died down a bit, but definitely most of our family went to see the museum after that.

SG: Do you think there's anything you learned when you were there with school, to then use it when you went there with family?

Dorota: Oh yeah, when we went with school, we got these little notepads and everything and we got to take photos, which were then turned into stickers that we could stick into there. We could write down different information that we found out, so yeah, I definitely learned some stuff and I brought the notepad with me.

SG: You brought the thing with you.

Dorota: And when we went with our family, just before we actually went around the museum, we had to go into this one room and they gave you like this little pack with a book and they gave a little notebook to my brother and sister as well. They always wrote a bunch of stuff down every time they saw it and yeah, so we learnt a lot of stuff in school and when it was just with family.

SG: And who led the day when you were there, who was the leader, or who decided where to go and things like that?

Dorota: Most of the time, well, at first, before we went to all of the different places, I didn't know about, I was kind of the leader. I was like, 'oh, mum, I went here with school and it was really cool, can we go there and see it' and then after that, none of us had a clue where we were going, so we all sort of just went, let's just go to that place, because we haven't gone there yet, so we all decided at once and all that.

SG: Did you tell them much about science or the objects when you went to the museum?

Dorota: Yeah, my brother and sister, I definitely told them a lot about it and sometimes I told my mum about different stuff, but my mum and dad sort of just read the stuff themselves. Sometimes, I would tell them to go and see something, because I found out about it, it was quite cool, but it was mainly my brother and sister.

SG: OK, do you often do that, do you often try and teach them and tell them about things?

Dorota: Yeah, whenever I find cool stuff on the Internet or at school, I always come home and I'm like, mum, I've found this out in school today, did you know Einstein was born on [inaudible 0:13:24] or whatever. I don't know, that sort of stuff and I'm always telling them.

SG: How old are your siblings, your brother and sister?

Dorota: My brother is six and my sister is four.

SG: And when you went there with your family, were there any parts of the visit you particularly liked or you particularly disliked, if you can think of any?

Dorota: Parts of the visits I, I've already said about the parts of the visits I liked, the cinema and that…

SG: Yeah, then maybe if there's anything you didn't like so much, you thought it could be different.

Dorota: I don't know, I don't think there's anything I didn't like. I think the stuff that I already saw in school, which sort of, I don't know, it's not that I didn't like it. I still found it interesting, but I already knew everything that was there and I already saw it all, so maybe that.

SG: If you were in charge of organising an event like that, would there be anything that could be done better, to make it more helpful for a family like yours, if you can think of anything?

Dorota: I don't know, I don't think so, no.

SG: That's fine. We know from some research that some people see places like the [museum name] as places for posh white people, what do you think about that?

OK, no, I wouldn't say that. When I think of science museums, I mainly think of it as a place for people to go and explore and learn new stuff, I never think of it as a posh place for white people or something. I kind of think of it as a little fun place to sort of learn new stuff and do experiments.

SG: How are you in general getting on in science, you think?

Dorota: Yeah, I'm getting on well, yeah. I love science, I do love it. I find it really interesting. There's some stuff that I find more interesting than others, particularly space, I'm obsessed with space…

SG: Space?

Dorota: Yeah, we've got a science fair and my whole science fair project, I'm doing it on space, nothing but space. So yeah and my teachers are always saying I'm like a little Einstein, because I'm always learning about stuff about Einstein, like the idea of general relativity and all that.

SG: Is that a science fair here, organised by the [school name]?

Dorota: It's organised by some of the science teachers. This is the first time they've done it, so they're just like seeing what people think of it and all that.

SG: What are you going to prepare, do you need to do like a project, or how does it work?

Dorota: Yeah, have you ever seen like American science fairs, where you've got those sort of big, those boards, where there's like three sections, you've got one in the middle, two on the side and then they usually do it on volcanoes, they make a little volcano…

SG: Yeah, I've seen that before.

Dorota: They write stuff in the background about. That's kind of what we have to do, we have to prepare a bunch of information with data and our question and the conclusion. Then we're going to stick it onto a little board and we can even make a little demonstration or a project or something.

SG: Nice, would you say you are a science person?

Dorota: Yeah, definitely.

SG: Yeah, what do you think makes someone a science person?

Dorota: Curiosity probably, sort of curiosity, I think thinking about how the world works and I'm always going to my mum just like, I don't know, 'mum, how does gravity work?'. Which I now know, because of general relativity. Or I'm like, how did the Earth come to be made and all that. Because I believe in God, so I believe God made it, but in terms of scientific points of views, I'd like to see the different theories, that sort of stuff. And I'm always sort of wondering about different things, so yeah, I think it's curiosity really.

SG: Cool and what do you think about the science you learn at school, what do you think about it?

Dorota: It's kind of, I don't know, there's stuff that we learn about that I really love and then there's stuff that we learn about that, I do find it interesting but don't like it as much. Like I'm not that interested in physics, like, not space, like forces and sound, I'm not really interested in all that. The only physics thing that I'm interested in is space, but then when we do maybe chemistry and seeing how different acids react together and that sort of stuff, I love doing that. So it's sort of up and down and it also depends on the kind of teacher you have. If you have a really strict, mean teacher, you might not enjoy it as much, might not enjoy the lessons. If you have a really fun teacher, who's always like, 'OK, everybody, get up, we're going to do this activity together', then the lessons are obviously a lot better.

SG: Yeah, what are your teachers like?

Dorota: They're fun. Mr Bramley, we haven't had him all year, he had to sort of step in because of exams and all that, he is really, really fun. There's this sort of thing that like teenagers, they always like, we say someone is safe and what we mean by that is, like, in terms of teachers, if you do something bad and you say that they're safe, then it's like saying, they won't care. They won't give you a detention, they'll just sit there, just be like, 'you know what, I was a teenager once, I know what you feel like, it's OK'. You know, it's that sort of stuff. And Mr Bramley is kind of like that and he's really fun as well, he always helps you out. In exams, we never do them in exam conditions, we always work together in groups and all that, even though we're meant to do it alone and everything. He sometimes gives us the answers and everything.

SG: Is he different to Ms Richards?

Dorota: Ms Richards, our other teacher, I don't know. Ms Richards, she's fun and all that as well. But when she has to, she is strict. When she has to be strict, she is strict. When someone's doing something bad, she knows it's bad, so she says, 'you've got a detention or you've got a warning'. But when you're being good and all that and you're listening, she lets us talk to our friends and that sort of stuff. She's more strict but still fun, yeah.

SG: Do you enjoy one or the other approach more, stricter or more fun?

Dorota: I always really enjoy Mr Bramley's one more, because he lets us like talk to our friends and he helps us out more. But I think in terms of Ms Richards's sort of approach, I think that one is better, because it means we learn more, instead of just chatting with our friends all day. I do appreciate that one more.

SG: Interesting, to what extent do you think the science you learn at school is useful for your everyday life?

Dorota: To every extent actually. Well, when you're younger, you don't really do many scientific stuff, you know. Cooking involves science and you don't do a lot of cooking and you don't learn where to store certain foods, because of bacteria and all that. You don't do all this stuff when you're younger, but then when you're older, you start doing cooking, maybe even washing up, knowing which kind of liquids to use, which ones can burn your eyes and that sort of stuff. That can be, you know, when you're older, you're doing all this different stuff and you need to know the science of stuff. You need to know whether it's bad for you or not. Also, if you're going to do a scientific related job, maybe if you want to be an astronomer or physicist or just a simple science teacher, then it's obviously a lot more helpful.

SG: Do you think you might want to do something related to science?

Dorota: Yeah, definitely. I'm mainly thinking of, along the medical, sort of, just being a doctor or something. Sir said I should definitely be a doctor, because we once had this, we were learning about like bacteria and vaccines, how they work and all that, and we had a test and I got full marks. I got the highest level and everything and that's the only test I ever got full marks on, so he's like, 'you should be a doctor'. But if I could, I would love to be an astronomer, because of my, I love learning about different stars and the constellations. And I guess there's some space involved as well, so yeah.

SG: Do you know what you would need to do to become an astronomer, do you have an idea about what that would involve?

Dorota: About becoming an astronomer, no, not really. I have got an idea of what I would have to do to become a doctor, because I watch a lot of shows, but also I have researched it on the Internet. In terms of maybe becoming like a physicist, some sort of scientist, an astronomer or something, I'm not really, maybe something in university, you might have to [inaudible 0:23:22] job. I'm not sure, you know, get good levels in science in your GCSEs, that sort of stuff. I'm not really that sure about what I'd have to do to become an astronomer but…

SG: Do you normally get information about it from your parents or your school, what do you think is the main resource for that?

Dorota: The internet actually.

SG: Oh, just yourself…

Dorota: Yeah, I like to research it myself, I like to do stuff for myself a lot, but I've also got a cousin who's in university …

SG: OK, here in the UK, so…?

Dorota: Yeah, so I sometimes ask her what it's like and the kind of stuff you can choose and how long it takes and all that. She's not necessarily practicing to be like a doctor or anything, like I want to be. She's practicing to be a photographer, which I would like to do as well. I'm really artistic, so she can't really tell me much about what I want to do. But she can still tell me, like, the different choices you get and how it all works and all that. So whenever I'm curious, then I can always go and ask her.

SG: Cool and what sort of person do you imagine to be a scientist, do you have any kind of images, characteristics that you associate with a scientist?

Dorota: Well, stereotypically, you probably think someone who's really clever and who did well in school and then when they're older, they wear these white lab coats and all that. But for me, being intelligent has to have something to do with it. I get a lot of inspiration from Einstein, mainly because he just was not good at Maths at all. Yet he was still a really, really famous, I think he was a physicist or something. He came up with a lot of equations and all that that even I don't understand and I'm a person who generally gets quite a lot of good levels in Maths. Him, he obviously struggled with it and he came up with all these equations and stuff and I'm like, 'how did he do that?'. So he's a big inspiration to me.

So, I don't think it's, you have to obviously be intelligent in something, and you have to know about something. You can't just say, 'I'm going to be an astronomer', without even knowing what a star is or something like that. But you don't have to be, you know, your IQ doesn't have to be 240 something, it can still be just average. Then there's also, you have to enjoy it. You can't be the kind of person who's like, 'I'm just being a scientist for the money' or something, you have to genuinely, yeah, find it fun to do and like be curious about it, that sort of stuff. I don't know what else, maybe sensible people I think, yeah, that sort of stuff.

SG: Do you think boys are more likely to go into science than girls, what do you think about that?

Dorota: No, it is stereotypical to think that, because many of the great scientists are boys. But then there's also scientists like, I think her name's Madam, oh God, the one that found out about cancer through getting radiation or something, Madam Curie or something like that…

SG: Marie Curie.

Dorota: Yeah, so she's also a big inspiration to me, because she's a woman and all that, so I don't think boys are more likely, I just think that boys are more famous for some reason, I don't know why …

SG: And do you know what your parents think about science, like is it important to them?

Dorota: My dad, because of the country that he comes from, he comes from a very poor country and all that, he…

SG: You're from Czech Republic, you mentioned?

Dorota: No, not all us, my dad, he's from a place called Kurdistan, not a lot of people know about it. So he didn't really get to go to school a lot, he didn't learn a lot of science and all that. So to him it's sort of like, he doesn't think about science a lot. When I say to him, he drops and apple and he's like, 'how did that apple drop down, how does it work?' and I'm like, 'gravity' and he's like, 'what's gravity?'.

Science isn't very important to him and to my mum. She is, again, she's not as curious about it as I am, but there are some stuff she finds interesting. There are some stuff where when she finds it out she, you know, she does find it quite interesting. But again, it's not really that important to her.

My brother and sister, they're still growing up. My brother is sometimes coming home just like, 'mum, I learnt about how rocks are made today'. He is quite curious about it. And my sister, she's still in nursery, so she doesn't do a lot of science. But whenever I tell her something scientific, whenever I say, 'the way a light works is because the light shines into your eyes' or something, she's always like, 'oh, that's really cool, that makes sense'. So my brother and sister find it really interesting as well.

SG: And do you have any family members that work in science, in science related jobs?

Dorota: No, not really, I don't think so. From my dad's side of the family there's not many people. From my mum's side of the family, they live in Czech Republic and you don't really get many jobs there and everything is really expensive there. So my family there, they're sort of, they just have standard jobs, maybe working at the shop, at the counter, that sort of stuff. I don't have many family members working in the science industry.

SG: Do you know what kind of expectations your parents have of you, like what they want you to be?

Dorota: They say I can be what I want to be. They're saying, you know, try your hardest. But if I say to them I want to be maybe a scientist or a nurse or a doctor, they will say 'that's a really good job, well done'. They will help me throughout. If I say I want to just work in a shop at a counter, that sort of stuff, they won't be saying 'it's a small job, you don't get that much money, why don't you do something better'. They will still help me out and they'll say, 'OK, if that's what you want to do, then do it'. But sometimes, they will sort of throw a few hints in there, just like, 'did you know that being a teacher means you get lots and lots of money', just randomly throw in a few hints in there. Just so that I can want a better job, that sort of stuff. So, they don't necessarily have any expectations, they say I can be what I want to be, but they do try and sort of push me to do better.

SG: Do you think they hope you'll go to university?

Dorota: Definitely, but I want to go to university, I want to go to college and that sort of stuff. My mum never went to college or anything. She says it's the worst choice she ever made. And it's not just because of that, I generally love going to school and I want to have the best future I can have. It's not just because of my parents or anything, I do want to go to university and everything, but if I did say I don't want to go to university, my mum would probably got a little mad.

SG: And would you say you ever do any science related activities outside school, you mentioned already you kind of go to parks and zoos, like is there other things or do you see that as being related to science?

Dorota: Outside of school, science related activities, if watching documentaries over and over again that are always to do with science, then yeah, I do. Every time there's an advert for some sort of documentary, maybe about dinosaurs or that sort of stuff, is his name…?

SG: The presenter of nature shows, David Attenborough?

Dorota: Yeah, him, I love him and every time some sort of documentary comes up with him in it, I always watch it. Even if it's just about different grass types or something, I still watch it, because he just makes stuff interesting. Documentaries, I don't know, sometimes I go on the Internet and I like do fun and easy to do science experiments at home, and sometimes I do that when I'm bored.

SG: OK, you just find it yourself and do them.

Dorota: Yeah and my mum, for Christmas and my birthdays, she always buys me at least one science kit. I've got this one where you can make these cool crystals and everything and she always buys me some sort of science kit and all that sort of…

SG: Do you do it together then or do you just tend to do it by yourself?

Dorota: I like to work by myself, I'm kind of one of those people who likes to do stuff in her own way by myself. So I do most of that stuff alone and I find it really interesting, but sometimes she helps me sometimes…

SG: Do you talk to your parents much about science in general, like at home, do you speak about it?

Dorota: I don't know, not really. Sometimes when something scientific and exciting comes up, I might go up to one of my parents and say, 'oh, did you know there's a mission to Mars' or something. But it's not one of those things that we always have conversations about.

SG: Yeah, we're nearly at the end, sorry, I kept you a bit long, but it was really interesting talking to you…

Dorota: That's OK.

SG: Being involved with this project, do you think it made you see science in any kind of different ways, sort of through the museum?

Dorota: I don't know. Definitely, at first I thought science was sort of about, I don't know, making little potions out of acid or acids and all that sort of stuff and wearing a lab coat and goggles and dissecting and all that. Then going to the museum, I thought it was some sort of history museum at first, something like that and then they told me that it was all to do with, it was all to do with science, the textile stuff, we had this demonstration on how, using science, they could make different types of threads and how the machines worked and all that. And I was like, OK then, science has obviously got, there's more to it than just, you know, mixing stuff and I don't know, dissecting different animals and all that, there is more to it than just that. There is a sort of engineering side to it and a textiles sort of side to it, I never thought textiles and science could be related and then I went to the museum and I was like, oh OK…

SG: Do you think there were any of your classmates that were much more engaged with doing kind of activities there than they would in the science classroom?

Dorota: Yeah, definitely. For some of them, yeah, I've got this one friend, in science she never listens and she's always just maybe on her phone or something like that. She gets into trouble and when we went there, we partnered up and we did the work we were meant to do together. She kept on going round and she was like, 'Dorota, I've found a coat that's made completely out of daffodils' or, 'oh my God, that plane is so big, I can't believe it actually worked if it was just made out of little pieces of wood' and she was really interested in it.

SG: Who was that?

Dorota: [Female name].

SG: Oh, [Female name], yeah. She was your pair, right, for the thing?

Dorota: Yeah.

SG: If we were to do something similar again, what would you say would make it maybe better for you or more interesting?

Dorota: Well, when we do go on the trips, maybe, I don't know. There was, even though we got to search more of like vast areas of the museum, there was still, the museum has these sort of little blocks. Do you know what I mean? Like these different areas and we still have to stay in one little sort of block, even though we got to go on the different floors and to the different rooms and all that, we still had to stay in that one area. It would be quite cool if we could go round and see other places, even if the teachers had to guide us through first, which would be cool. If we could do more science experiments, rather than just, I don't know, going round and writing about it, maybe being able to put our goggles on and a lab coat and do a few different experiments, seeing how DNA can be split up or that sort of stuff. That's probably it, yeah, being more interactive and seeing vaster areas, yeah.

SG: Yeah, that's been very interesting, thank you so much, it was very lovely to talk to you …

Transcript of the follow-up parent interview with Cordelia's mum

14th May 2015
Over the telephone

SG: So, I want to ask you a few questions about what was it like in the museum and then a few sort of in general about science and how you think Cordelia's doing at school. To start with, what did you think about the visit to [museum name] that you went to, was it two weeks and a bit ago?

Cordelia's mum: I thought it was very, very interesting and very educational. I was quite surprised, because I've not been there for a long time, you know, they change a bit, so yeah, it was good.

SG: Yeah, you have been there before, some time ago?

Cordelia's mum: A few years ago, yeah.

SG: OK and when you said it was quite educational, what sort of things you felt you sort of learned or what did you mean by that?

Cordelia's mum: I think, like, you know like the different things, like the [inaudible 0:01:13], you know like more, I think it's like the younger ones and the bigger ones, but I think for the younger generation that go there, just like some of these things that you were looking at, you know like when they were going around in a circle and [inaudible 0:01:32] you know, you had to [inaudible 0:01:36] and just the different things about it. I just thought it was really good for children, trying different things out and everything and you know. It was good.

SG: Yeah, thank you. And what do you remember doing when you were there, do you remember the main sort of parts where you went to?

Cordelia's mum: I went to all of it, to be honest with you. The science bits, we went to the trains, we went all. And I tell you what was really good, it is 4D or 5D…

SG: 4D, the theatre thing.

Cordelia's mum: 4D, the 4D film, which was brilliant, I've never seen a 4D film before and I thought it was absolutely brilliant, yes.

SG: OK and what was the reason you decided to go, was it your idea, was it Cordelia's, what do you think were the main reasons?

Cordelia's mum: Well, Cordelia told me about it and then, like, we do go places anyway. So I thought, oh, that would be nice, to go back to, you know, like to the museum, because we've not been for a long time. so partly Cordelia and then partly me as well.

SG: And did you talk much about, with Cordelia before, what sort of things they were doing when they went with the school? Did you talk much about that?

Cordelia's mum: Yes, she was telling me about the different things, you know, like [inaudible 0:03:06] getting involved and everything. So yes, I spoke to her about it.

SG: OK, and was it anything at all surprising in terms of like her work or what she was like in the museum?

Cordelia’s mum: No, nothing surprising about it. I know how she is and what she likes and that.

SG: Would you say she was the one leading the visits?

Cordelia’s mum: Oh yes, she does really good leading and the man that came round with us, what was his name…

SG: [Researcher’s name].

Cordelia’s mum: [Researcher’s name], yeah, I don’t know what impression he got of Cordelia, but she led us round and spoke about the different things and everything. So yes, she's done really well.

SG: Is that how it would usually be when you go to the museum?

Cordelia’s mum: It was different in that situation. Normally, if we’re just going somewhere, then we’ll just go looking. But she like took control of it, which was a good thing. It built her confidence as well.

SG: Cool, and do you remember speaking, was she talking to you about science at all or the objects? Do you kind of remember what sort of things was she able to tell you when she was leading around?

Cordelia’s mum: Oh, she was saying little bits about them, you know, like what they were doing and explaining and that. Some of the items and that, so she was explaining things to us, you know, like what she's been doing and what she was involved in.

SG: Have you talked much about the visit with your family since?

Cordelia’s mum: Yes, because I've already said to different people that we know, especially the ones that have got the younger children. That it would be worthwhile going and taking them, because they'd have a fantastic time just looking at the different things and trying them out. It’s a good thing for children to get involved into science as well, especially at a young age.

SG: Yeah, is that something that was important for you when maybe Cordelia was younger, to get her involved with science?

Cordelia’s mum: Well, yeah, I mean, you know, like getting them involved in science and like, because we've always gone to museums and art galleries and things. But really, from that one there, how they’ve changed it, there wasn’t much museums with science in them. Do you know what I mean, you just find little bits, but not to the extent of the museum.

SG: Were there any parts that you didn’t like so much?

Cordelia’s mum: No, I couldn’t say there was anything that I didn’t like, to be honest.

SG: OK, maybe anything that if we did a similar thing again that would have been helpful for you and whoever you came with?

Cordelia’s mum: No, I think everything was absolutely fine, everything, yes.

SG: And what do you think about going back for another visit, do you think you might do that with?

Cordelia’s mum: Oh yeah, because even though you’ve been round the first time, if you went again then, you know, you would still find it interesting.

SG: Yeah and what would you say you and, you went with Cordelia and was it a friend and a relative?

Cordelia's mum: A friend and the brother's girlfriend.

SG: What would you say you and your friends and sort of relatives got out of the trip?

Cordelia's mum: Just seeing the changes in the museum and the different activities that they'd got on, you know. Like when you're walking round and you're seeing all the children getting involved even at a young age, then it's a good thing.

SG: I have a few questions now about Cordelia and how you think she's getting on at school and whether science is something that plays a big role in her life or not. So, how do you think Cordelia is getting on in science at school?

Cordelia's mum: Well, as I say, in school, she's not a big lover of the science. I think the difference is on how they explain it in school, it's not as good as what you'd see, like in the museum, you know. Like it's a bit harder in school, because there's that many people, so yes.

SG: Do you think she gets more involved with science when she's outside of school?

Cordelia's mum: Yeah, I would say so.

SG: Do you talk much with her, whether she enjoys science at school or any particular topics that she might have enjoyed?

Cordelia's mum: Yeah, we do, I mean, she does enjoy school and she does like enjoy English and like drama, she loves drama. Most lessons she does love, you know what I mean, she's just at the moment because of everything going on, just a bit, everything's at the moment a bit low.

SG: Yeah, I hope so … Do you know that she has any ideas what she wants to do in the future?

Cordelia's mum: She wants to become a midwife.

SG: A midwife, OK.

Cordelia's mum: Yes.

SG: Is there anyone in your family who does that job…?

Cordelia's mum: No.

SG: That she got an idea from?

Cordelia's mum: No, she just decided that she wanted to become a midwife, yeah.

SG: What sort of jobs do you think would suit Cordelia?

Cordelia's mum: Besides being a midwife?

SG: Mm-hmm.

Cordelia's mum: She likes animals and yeah.

SG: How involved would you say you are with Cordelia's schooling, like homework and things like that?

Cordelia's mum: Very involved, we help her as much as we can. And her sisters do and my son's girlfriend, she helps her as well. We do get involved, yeah.

SG: And do you talk much about science to her?

Cordelia’s mum: Bits, I wouldn’t say we've talked loads about science, but we just talk about different subjects and we do talk about science a bit. When she does experiments and things she’ll come across and sometimes she tries them out at home, so yeah, we do.

SG: OK, does she maybe talk about science more with her dad?

Cordelia’s mum: All of us, we’re just all, at different times. I'd say it’s all of us.

SG: Yeah and what do you think about Cordelia kind of going into science, becoming a scientist, do you think that was ever in her plans?

Cordelia’s mum: No.

SG: Would that be something that you think might suit her, if she decided?

Cordelia’s mum: I don’t think it would suit her, because she's not, I mean, I know she’ll have to have like biology and everything behind her, but it’s not something that she would take as a job, you know. Like my oldest daughter, I think with her, she was very good at forensic science and she got a good grade, she loves science, so I mean, you know, so there’s difference, isn’t there?

SG: Yeah, why do you think it would not be suitable?

Cordelia’s mum: Because she doesn’t have as much confidence in science as what she does other subjects, yes.

SG: OK and what sort of activities do Cordelia and your other children like to do or you maybe do as a family?

Cordelia’s mum: Oh, we go round like museums, as I say, art galleries. She goes swimming, she does some tennis, she goes to [inaudible 0:13:05] school and they do all different activities, so she likes a wide range of things.

SG: Do any of these activities would you say involve science, is any of it kind of science or…?

Cordelia’s mum: I wouldn’t say, no.

SG: Do you ever watch any, like, maybe science TV or have like extra science books or anything like that maybe?

Cordelia’s mum: We have loads of books in the house, science and all different books. I mean, I wouldn’t say we watch a lot of science programmes, because they don’t have a lot of science programmes on television anyway, unless you’ve got Sky or whatever. But I mean, like (Meacher ? 0:13:51) and all that lot, we watch loads of those, but as for science, you don’t really get science programmes on television, you know.

SG: Cool, thank you and what do you think of if I say the word science, what would you say science is to you?

Cordelia’s mum: Experiments and like, you know, to do with the stars and all like atoms and all, you know. Science can be anything really, when you put your mind to it, numbers, because numbers are attached to science, aren't they? And you know, so there's a lot of aspects to science really.

SG: Is it something you find interesting yourself?

Cordelia’s mum: Parts of it, but I wouldn’t say I'd go all out for science, you know what I mean? But don’t get me wrong, I find anything interesting, you know, if something was on or I heard something that was interesting then fair enough. But, you know, I'm more hands on, like, as I say, we went to a museum, now that was interesting, because there was lots of different things, but I think it's more interesting if you go and see things than sat reading a book. You know what I mean, so you get more out of it through doing it.

SG: Yeah and are there maybe any particular areas sort of within science that you've found very interesting?

Cordelia's mum: Me personally?

SG: You personally, yeah.

Cordelia's mum: [Laughs]. God, it's a long time since I've done any science, so back then it wasn't [inaudible 0:15:37] as it is now. [Laughs].

SG: That's fine, we'll move on. May I ask what you do, just to see if your work maybe is in any way…?

Cordelia's mum: I'm a carer.

SG: And do any of your friends or family have a job related to science?

Cordelia's mum: Well, they don't, no.

SG: Would you say that some of them are interested?

Cordelia's mum: I think the younger ones probably while they're at school and everything, but apart from that, no, I'd say no.

SG: No relatives or friends in anything, healthcare or engineering or…?

Cordelia's mum: No, I mean, my son does mechanics at college but no, so…

SG: Lovely, I am nearly at the end. I just have a few questions, just for us to sort of get a bit of background information about the families involved. Again, it's all confidential and will be anonymised.

Cordelia's mum: Right, OK.

SG: May I ask how old you are?

Cordelia's mum: I'm 47.

SG: How would you describe your ethnic background?

Cordelia's mum: I'm white, British.

SG: English is your first language?

Cordelia's mum: Yeah.

SG: Right, how many children do you have?

Cordelia's mum: Four.

SG: Four and how many of them live in your house?

Cordelia's mum: Just Cordelia and [male name], two.

SG: May I ask how old they are?

Cordelia's mum: [male name] is 17 and Cordelia is 12.

SG: Is it just the three of you that live in the house?

Cordelia's mum: Yes.

SG: OK, the three of you and may I ask what your highest level of education, like with age or like GCSEs or A Levels?

Cordelia’s mum: Yeah, I just had my GCSEs and everything, so yeah, GCSEs.

SG: And I think that’s all. Is there maybe anything else on the topic that you wanted to talk about or mention, anything else you think may be useful for us to know, if we do similar things again?

Cordelia’s mum: Well, I just think it’s a very good thing that you did that and it was very, very enjoyable. We've spoke about it a lot to different people, just to encourage them and I thought, yeah, it was really, really good. I was pleased with the outcome, that Cordelia enjoyed it so much.

SG: I'm pleased to hear that. Thank you very much for your time and talking to me. We might still work with Cordelia’s class, depending on sort of if they separate them and put them a bit differently, so maybe we’ll see you again for some other activities in the next year, if you're up for it.

Cordelia’s mum: OK, alright then.

SG: Have a lovely evening, thank you very much again.

Cordelia’s mum: And you too, thank you very much for phoning.

SG: You're very welcome, take care.

Cordelia’s mum: OK, bye bye.

Field notes from science lesson observation at the Northfields School

2nd July 2015 – 10.00 – 11.00 am

10.05

I come to Mr Cohen's class (3B) and he is standing by the door receiving some late students.

Mr Cohen introduces today's topic – electricity (why would the light bulb not shine in a situation shown on the slide). [Male name] loudly 'how do you draw a bulb?', seems engaged. Jasmine is flicking through her notebook. Aliyah is one of the first who has finished the task, she proudly shows her answers (in a notebook) to Mr Cohen as he walks around. He nods in approval.

When Mr Cohen asks the class to give answers, [male name] volunteers, then [female name].

10.12

They watch a YouTube clip on lightning (a guy gets struck by lightning when in a car, as an experiment). It is loud and students pay attention. Mr Cohen encourages students to think about what they already know about lightning.

Caitlin is swinging in her chair, making funny glamorous gestures with her hands.

10.19

Learning objectives on the slide – they get 6 minutes to come up with the answers.

Sharifa is quiet and has not spoken a word to anyone since the start of the class.

Jasmine is talking to [male name] about storm, calls me over at some point to ask whether the thunder shines. I explain to her briefly that lightning and thunder go together etc.

Samira and [female name] chat. Alimah is looking out of the window.

[male name] puts his head on the table; Jasmine is drawing on his jacket.

Some other students are fighting over who stole someone's pen. Mr Cohen 'I'm trying to teach science to 30 year 7 students, can't be bothered to think whose pen this is!'

Jasmine is tapping with a pen. Sharifa is fiddling with some paper. Samira is trying to balance a pen on her nose, her and [female name] giggle.

10.25

Mr Cohen asks for volunteers, but then straight away calls Aliyah. She attempts to give an answer but it is wrong. She keeps holding her hand up afterwards, but does not get called again for the rest of the class.

[Male name] and [male name] answer some questions that Mr Cohen asks, about car and lightning.

Samira and [female name] hands up now too.

Mr Cohen mentions that they might see lightning later today as there will be storms, Jasmine loudly 'yessss!'

Jasmine volunteers to answer a question, says about how lightning goes up. She explains this is because 'the ground shakes sometimes'. Mr Cohen: 'what's that, a start of a song?' Jasmine argues: 'but why would the ground shake otherwise?!' [Reflection: interesting example, attempt to dismiss, then linked to singing – which is what Jasmine is all about!]

Jasmine is shaking her head, hair flowing everywhere, gets told of by Mr Cohen to calm down.

Lots of boys have hands up, as well as Aliyah, but Aliyah does not get called, just a few boys.

Alimah is chatting to her neighbour.

Mr Cohen introduces the new topic, voltage, and how they will be making their own lightning. The class is excited. Then he introduces a practical.

Jasmine is singing and dancing in her chair, playing drums on the table. Caitlin is spending a lot of time sorting out her long blond hair, making different hairstyles.

Mr Cohen calls 7 students to get the equipment; all boys come to get it. Alimah and Aliyah stand up a bit later to have a look if they could have a set as well (they were meant to work in groups), but all the things have been taken. [boys very much dominate the practical – other than [female] all other stations are led by boys.]

[female joined the class within the past few months so was not part of the project before. She seems to be very engaged with science – and Mr Cohen later told me her and Samira both got an equal grade, highest in the class.]

10.32

Jasmine is playing with the equipment, putting the 'crocodile clips' together. To [male name]: Listen!' She is impressed that she can hear the sounds it makes. Jasmine then acts having an electric shock, which gets quite a lot of attention from others on her table.

Samira packs her bag and moves to the other side of the table to sit next to [female name]. They seem to get along well. [Mr Cohen was later telling me that he was concerned about the two of them when [female name] first came, because there were some competition between them – but they have become friends and often work together. They are both Muslim girls, both with high grades in science.]

Sharifa, who is in the group with Jasmine, [male name] and [male name], has still not spoken a word. She quietly observes what the others are doing.

10.35

Samira suggests they try to set a piece of paper on fire with the sparks that are coming off when the two wires touch.

On the next table, Aliyah seems to have been left without a group.

Caitlin is not involved in the experiment. There is a lot of giggling as other are faking an electric shock.

Jasmine starts singing in a high pitch boys, teases [male name] who is playing with the big nails (part of the experiment).

There is a lot of noise in the classroom.

10.40

Mr Cohen counts to calm them down.

The experiments continue to be run by boys, with most girls being off task. There are a lot more boys in the class than girls. [Reflection: I talk to Mr Cohen about it later, who tells me this is indeed the case across the school, as there are more girls' schools in the area than boys' schools – so they get much more boys than girls. This is an interesting point in terms of my PhD: girls' school vs. boys-dominated school].

I spot that Sharifa and Jasmine are still wearing the [science museum] badge.

Mr Cohen tries to get attention again. To Caitlin: 'Caitlin, why do you think we are waiting?' Caitlin ignores him for a few seconds and carries on playing with her pen.

They start a new stage of the experiment. A few boys and [female name] go get the equipment (the now need to attach a light bulb).

Sharifa is now writing something in her notebook (there are questions on the slide that they are meant to answer).

Mr Cohen asks [male name] to tell the others why he is counting. [Male name]: 'You want us to calm down and have our attention.' [Mr Cohen has previously picked [male name] as an example of good behaviour; [male name] is often disruptive in class but when he does well he always gets a lot of praise.]

Mr Cohen gives a brief introduction on voltage.

Jasmine is fixing her eye makeup while Mr Cohen is talking. Aliyah has her head on the table, looking towards the back of the classroom. She is playing with [male name] [flirty?] – they keep putting their hands on each other, waiting for the other to push them off, and then do it again.

Samira is making an installation from the experiment material.

10.50

Jasmine is singing again, in a funny noise and using made up words.

[Female name] and Samira and talking about the experiment, seem engaged. [Female name] is clearly the leader of their team.

Sharifa is copying text from the slide. Jasmine is playing with the equipment. Jasmine 'I just don't understand!' She soon goes back to singing and dancing.

A few students complain that their meters do not work. Mr Cohen tells them to start cleaning up and returning everything back nicely – if they do not finish in time, they will be late for lunch.

[Male name] hits Jasmine. Jasmine calls Mr Cohen 'Siiiiir!' Mr Cohen is busy talking to some other students. Jasmine stands up and shouts at [male name] 'don't ever touch me!' and moves to the next table.

10.55

Mr Cohen to Junior: ‘What did you learn today, [male name]?’ [Male name] is looking out of the window and does not pay attention.

The students (all boys) bring the equipment back.

Mr Cohen: ‘That was great year 7, thank you very much!’ [a lot of praise, and Mr Cohen tells me after that they were much better behaved that usually.]

Mr Cohen calls students one by one to leave the classroom.

Field notes from Niya and Larisa's family visits to the science museum observation

Sunday 26th April 2015 – 9.30 – 16.30

Brief summary of the day:

- Facilitated by [science museum educator 1] (9.30 – 14.00) and [science museum educator 2] (12.30 – 16.30)
- Room set up on 2nd floor of the main building (conference rooms): iPads with students' videos, snacks, notebooks, leaflets on a lanyard (new!), vouchers (£10 food per person, tickets for 4D theatre), Kitchen Science book, SM pens, stickers, museum maps
- Ms Richards was there 11.00 – 14.00 (she encouraged students in class to come by telling them they get to hang out with her on the weekend; she was there most of Saturday as well)

Two families:

- Larisa came with her mum, younger sister (3 y.o.) and family friends (3 adults, 2 children – poor English and hesitated signing forms, but they spent more of the visit separately. They stayed 12.45 – 15.15 (I left them at 14.10 as they went for lunch to join Niya's family), they went to 'Experiment' (interactives), 3D printing exhibit, 4D theatre. [fun day out, feeling special, low engagement with science/museum]
- Niya came with her mum, dad and three older siblings: sister (19 years old), sister (year 12), brother (check age?). I have consent for everyone (dad signed one form for three under-18s). They stayed 14.00 – 16.10, went to [gallery names] (they saw Niya's object).

There were signs in at the [museum name] entrance about the Enterprising Science and both families found us easily.

Notes from waiting for the family/talking to Ms Richards

[Science museum educator 1] and I set up the room at 9.30. Ms Richards comes in at 11.00. She says she was quite surprised how engaged some students were yesterday, particularly Cordelia (observed by [researcher name]), who is usually quiet in class but took a leadership role yesterday and took mum around all the object she knew from the school trip. She was also surprised by Larisa's video – Larisa is usually not very engaged with science and does not participate much in class.

Ms Richards mentions that Mr Bramley is planning to come with his two children, which she is really pleased about (he does not come at the end). She also mentions that a few students said they would love to come but they do not have an adult to come with them – Sarah suggested they come together without an adult.

We chat about families that came yesterday; [science museum educator 1] says all were happy to hear form us; at least one parent had an OK level of English so we can phone them.

Ms Richards think that while for some students it might have been a draw that she was coming to the museum, some might have been pushed off by it. She told them she would be there but that they do not have to speak to her if they do not want to.

LARISA’S FAMILY VISIT

Larisa’s mum is originally from [country name] and has lived in the UK for 9 years (first Southampton briefly, then Manchester). Larisa was in a pre-visit focus group: she is not very keen on science, wants to be a writer, her mum lets her be whatever she wants (although she warns her that writing might not make a good living). Both Ms Richards and Inga were surprised/impressed to see a very confident performance from the school visit to museum. Larisa and her friend [female name] (both tall, confident, energetic girls) did a very theatrical performance about Novelty.

Larisa is wearing a mic, I leave the mic on her until the end of their visit at 15.15.

12.45: Project room

Larisa arrives in a group of 8: her mum Inga, her sister [female name] (mixed race, 3 years old/nearly 4, in a buggy, Inga remarks younger sister is very lazy – Larisa was much more lively and energetic when she was [female name]’s age), a couple in their thirties with two young boys – one mostly in a buggy and a middle-aged woman (who tells me she is on holidays here).

They walked to MOSI.

[These are Inga’s family friends from home. Their English is not very good and as I try to explain consent forms on our way down to the ‘Experiment’ gallery, they keep telling me they are ‘just here with Larisa and her mum, not for the anything. They spend most of the visit in two groups, Larisa, mum and sister together, and the rest together. I do not get consent for the five non-family members, so I keep notes for Larisa’s family only.]

12.55

After some encouragement by Alice and Ms Richards, the three younger children go to the snacks table and grab a few chocolates and bags of crisps each.

Inga is keen to see the video from the school trip. Ms Richards tells Inga that Larisa was really good, [science museum educator 1] mentions Longdale High made some of the best videos of all schools. As [science museum educator 1] is setting up the videos on iPads, Larisa runs out, saying she finds it really difficult to watch herself in a video. Larisa and Ms Richards chat outside while the others watch the video Larisa and [female name] made about the object.

Larisa’s mum seems very impressed, all adults nod and grin. Larisa’s mum tells me Larisa is usually shy and quiet at home, she is surprised to see her so confident in the video [reflection: from what I have observed before, Larisa has been very loud and confident – but she behaves very differently today when out with her family!]

As we leave the room, Inga tells Larisa 'you're in charge, we're following you'. Larisa looks at the map on the lanyard and says they will go downstairs to the 'games' (the interactive 'Experiments' gallery on 1st floor, just underneath us).

13.00: Experiments gallery

The group disperses around the gallery, wandering around without engaging with any exhibit/interactive for more than a few moments. Larisa's mum is mostly occupied with her younger daughter [for most of the visit actually]; Larisa wanders around by herself. Here and there, she calls Inga to come over, e.g., to build interactive blocks. Larisa's mum comes closer, with a buggy, but does not get involved in the blocks building.

Larisa walks around most interactives in the room, giving each a very quick try before moving on.

They move to the next room. In the corridor on the way, there is an exhibit on sustainability. Larisa's mum stops at the screen explaining why sustainable bags are better than plastic ones (there are some cotton/linen shopping bags on display). She calls Larisa over and points at the screen; Larisa comes and stay for a few moments, but no further discussion happens. [This was one of the few occasions Inga took an interest into museum object/called Larisa over.]

13.05

Next to the 'sustainable bags' exhibition is the exhibition on 'sustainable solutions', displaying *Ecover* and other environment-friendly cleaning products. Inga and her friend both stop at the display for a minute or two, point at different items. The conversation happens in Latvian, but Inga later tells me it was interesting.

[A lot of conversations in the group happen in Latvian, with Inga occasionally translating to me what they talked about.]

Larisa's mum and Larisa's sister stop at the interactive where you need to find the right shape for the hole in the table [it seems like an exhibit for younger children]. Monika gets really into it and Inga encourages her. Larisa, again, wanders around by herself. One of the interactives she stops by for slightly longer requires fitting sets of tennis balls into what looks like a pool rack/triangle. Larisa then comes over to Larisa's mum and Larisa's sister and helps her sister figure out what to do. When Larisa's sister manages to get the right shapes, both Larisa and Larisa's mum applaud.

13.10

The group moves to the interactive where you can lift a Mini (car). Larisa's mum seems very interested, both Inga and Larisa give it a go. They stay at the interactive for a few minutes, watching each other move the car up and down, seem impressed.

13.15

Larisa says they will now go to the 4D. She has been there before and knows the way. Inga keep encouraging her to lead (hands off approach).

Larisa tells me that her family came to the museum together about 3 years ago last, but she has since been with school. Inga has not been to the 4D yet.

13.20: 1830 Warehouse

We walk across to the 1830 Warehouse building. Larisa asks at the counter what they need to do to see the 4D show. She is told they one show has just started and the next one is on in 20 minutes.

As they are deciding what to do, they spots the ‘penny souvenir press’. Larisa wants one ‘It only costs a penny!’ but Inga soon tells her that it costs an extra pound to do it. Larisa gives up at first, but then mum gets the wallet out and they press one penny with the museum logo. Larisa has by that point lost an interest in it, but Inga and her friends look impressed; they pass the coin around.

13.22: 3D Printing exhibit

Larisa gets the tickets for the 13.40 show and suggests they go see the 3D printing exhibit upstairs.

The group wanders around the 3D printing exhibit, pointing at different objects. Larisa takes Monika around, points at different objects ‘it is printed! 3D printer.’ [Role of teaching a younger sibling?].

Larisa disappears somewhere for a few minutes (another exhibition next door?), I walk around with Inga and chat. She asks me whether their food vouchers are only valid until 3pm given that their invite said 10am-3pm, I tell them they can used them until the end of the day. Inga looks at the watch and says she is trying to plan the rest of the day.

The group walks around, not much is being said. [It seem like they are mostly killing time, waiting for the theatre.]

13.30

The group moves to the side of the galley. Larisa’s sister is eating crisps after she has already had two chocolate bars. Inga tells her off for eating so much; she says she did not realised how much food she has taken from the room. They wait for Larisa to come back.

13.35

Larisa comes back to the 3D printing exhibit, I remind her that the show starts in a few minutes and they should probably go downstairs. She calls everyone and they make their way downstairs.

Larisa asks for directions at the cashier and gets tickets. As we get to the entrance, they hear that the cashier is just calling the ticket person to tell him that a group of 8 is coming who is on a 'special' ticket and he should let them in. Inga smiles. [It sounds like they are quite special, which they seem to enjoy!].

13.40 – 14.00: 4D theatre

They saw a show on dinosaurs, which sprayed water on them – everyone says they really enjoyed it. When I meet them after the show, Inga tells me they had enough and they will now go for a lunch, and that will probably be it. We walk together to the main museum building – as they head for the restaurant, I go back to the project room to meet with Niya's family who have just arrived.

[From the recording it seems like they spent the last hour at the cafeteria, then left home.]

I meet Larisa and family 15.10 when sitting down in the courtyard, they tell me they have really enjoyed the day but they are now ready to go home. Inga is happy to speak to us later.

Reflections on Larisa's family visit:

I have not heard any science discussion.

Larisa spent a lot of time going around exhibit on her own, not interacting with anyone.

They did not revisit any of the school trip objects.

Inga was mostly occupied by entertaining Monika, giving her snacks, trying to motivate her to not just sleep in the buggy.

The group was moving very slowly through the galleries, often waiting for each other, or for Larisa to tell them what to do next (the responsibility for the visit was with Larisa!).

Larisa was very different from how she was at school – she is usually full of energy, messes around with [female name], is often bossy and tells other girls what to do. She seemed quite disengaged today, and her mum was not engaging much either (with a brief exception of linen shopping bags and environment-friendly cleaning products) [I think Larisa mentioned in the focus group that her mum worked as a cleaner, maybe a link there – I need to check the transcripts]

NIYA'S FAMILY VISIT

Niya's family is from Pakistan, her dad is a nurse at the local hospital and her mum works in a nursing home (she was a stay at home mum until a year and a half ago, raising four children). Niya's oldest sister is studying biomedical science at Preston (and want to go into medicine), her other sister is in year 12 and thinking about becoming a doctor too.

They drove to [museum name], got parking reimbursement. The older daughter is the one sorting out family logistics (paperwork, money).

They are very quiet (a lot of the visit involved pointing at objects and labels, but not much discussion) and speak a mix of English and Urdu.

[I think they were a little uncomfortable with me following them at first, so I tried to start conversations – they became more comfortable and chatty as the visit went on, particularly mum and dad. At the end of the visit, mum invited me over to their house for Pakistani dinner.]

14.10: Project room

When I arrive to the project room, the family has already watched the videos from the school trip, and the oldest sister is just signing a consent form that Jenny gave her. [Science museum educator 1] encourages Niya to take her family around the museum.

Niya has come with mum, dad and three siblings. Only the older sister has been to [museum name] before. Others seem shy and a bit uncomfortable. When I was going to sign the consent forms, Ms Richards suggested if I can just do it with the oldest sister as others might not get what I want due to a language barrier.

14.15: Revolution Manchester gallery

They go downstairs to the Revolution Manchester gallery (the students spent most of their time here on their school trip to [museum name]). They go to the big plane model in the middle of the gallery; all point at parts of it, read the labels and chat briefly – they chat so quietly I can barely hear anything.

They go to the big machine for a few minutes, then to the 'Baby' computer. They move together in a group [all the time, no wandering on their own happen at any time during the visit] and spend a few minutes at each exhibit. Mum is pointing at the old computer keyboard, calling her son and Niya to come over. [Niya's mum seems to be interested in computers, she goes around to looks at a few computer-related objects.]

Niya (who is carrying a lanyard and a [museum name] bag] is taking the lead.

14.20

Niya has her notebook out and is writing something in it (for a few moments).

The family stop at the computer interactive in the gallery on the way to the 'Textile' gallery (where you can try to guess what you see under the microscope). There is not much discussion happening, but dad is pointing at the screen a lot and taking control of the game, calling his children to come see what is happening. On the screen, there is at some point an image of a cell. They play the games for a few minutes, and then move on. [I later find out that Niya's dad is a nurse, so looking at cells might be close to his work? Also, Niya's older sister studies biomedical science.]

14.23: Textile gallery

The family is moving on quite fast, they walk around the 'Textile' gallery. Niya's mum stops at the colourful fabric (yellow with bright patterns) and touches it. She tells to the girls 'see, cotton!'.

Niya's brother puts his hand the heat sensor (change of colour on the screen depending on the temperature of your hand), girls briefly stop at the exhibit on printing and dying fabric. Niya's mum tells me she finds one pattern very pretty; she mentions that in Pakistan, they have a lot of cotton. Often, the cotton is weaved by hand (she makes a hand gesture of turning a wheel), before being coloured. We talk about how beautiful Pakistani fabrics are. [Funds of knowledge, engagement through making links to their culture?]

Niya's dad checks with me is they need to finish by 3pm as the invite says, I tell him they are more than welcome to stay until the museum closes at 5pm.

We spend about 3-4 minutes in this gallery in total and then move to the lower level textile interactives.

14.27: Textile interactives

All get involved with the interactives; Niya's dad with Niya's brother, Niya's mum with the daughters (men and women separately). Niya's mum asks Niya's brother if he wants to go and see some airplanes next, he shudders his shoulders (not really caring what they do next).

Niya's brother and Niya say hardly anything during the entire visit.

They ask me what to do next and I say whatever they would like. We wait for a while at the entrance and I eventually show them on the map what the different options are (4D, air and space, other halls, school trip objects). After a few minutes, they decide to go to the 4D theatre next since they have the 'special' ticket for it.

On the way across the patio, I talk to Niya's dad. It was Niya's idea to come here today. He had a night shift last night so he was initially not so keen on going but 'you have to do things like this, it's important to take time' (referring to the MOSI visit). He says he is a little sleepy but he does not have to work tonight again so he will be fine. [He work as a nurse, his shifts change all the time.]

14.35: 1830 Warehouse

As we walk in, the family waits for a minute or two in the lobby. [I think quite unsure what to do next.] Niya does not seem very confident, so I help out and check with the cashiers what time the next 4D show is (it starts at 15.00). Niya's mum then asks me what they can do in the meantime, I tell them what is in this building. As Niya's sister interrupts me saying '3D printing!' pointing at the sign next to us, Niya's mum tells her off for it, saying that I was trying to tell them about it. I say it is really no problem and that 3D exhibition sounds like a good idea.

The family walks upstairs.

In the 3D printing gallery, they looks around at objects, moving around in a group again. Niya's dad makes a comment that he wants to see an actual printer, they talk very briefly about how 3D printed things are designed and printed (you make a plan on a computer and then print it out).

[They seem fairly disengaged otherwise, waiting for someone to suggest where to go next.]

14.45

They go downstairs to the gallery next to the 4D theatre, look at exhibits on 'immigration and public health' (dioramas with haunting voices of people suffering). Niya's mum calls Niya's sister and Niya and points at home of them, mentions about health being a difficult issue in the past [link to medicine again].

They walk through the rest of the exhibition very quickly, stopping briefly only at plastic loaves of bread and a model of Mellor Mill (old mill that burnt down), which they all pointed at [maybe they know about it from before?]. They return to the cashier to get the theatre tickets and go to the 4D show at 14.55. I meet them again after the show.

15.20: Lunch at the Warehouse café

On the way to the restaurant, Niya's dad tells me about his recent trip to Dubai as he was waiting for connecting flight to Pakistan and his love of high-rise buildings. He mentions that he wishes they could go back home more, but tickets are very expensive.

During lunch, we talk about Pakistan and Pakistani food (Niya's mum always makes a batch of food for the oldest daughter to take with her to Uni; she tells me they all bought chicken for lunch as they do not eat pork), my work and PhD (very briefly, I try to talk more about them). On a Sunday, they would usually go to 'church' (which I think meant mosque?) then cook food and stay at home.

Niya's dad asks me if he is allowed to take photos in the museum, I say yes. Naghat asks if everywhere, I say she is indeed allowed to take photos everywhere (she seems surprised). They have not taken any photos up until this point, but Niya's dad takes several in the remaining time they have in the museum (10 minutes in the next gallery). While we are still at the café table, Niya's dad takes a photo of everyone, wants me to be in the photo as well.

16.00: Air and Space gallery

Niya's brother seems very interested in the planes and cars, keeps pointing at different objects to his dad. Girls and mum seem less engaged with the exhibits. When we walk past a large airplane engine, Niya's brother rubs it, looks at the others with a big grin on his face.

They do a loop around the gallery, stopping briefly at exhibits they pass. The old cars seem to be most popular with the girls. They climb a staircase the back of the gallery to look inside a cockpit (all but Niya's mum and Niya's sister).

Niya's sister is now holding the notebook, looking at the questions in it and writing down the answers.

They stop for a minute or so at the Autogiro, a helicopter. Niya's mum talks about how unsafe this must have been.

Niya’s dad stops at most exhibits and looks at the objects closely. He touches a lot of the objects, like airplane wheels. [I think he is getting more comfortable as the time goes on.] Others walk on, he runs a bit in between the objects to catch up. Niya takes the family to the Flying Flee and says this was her object. Niya’s mum takes a photo of the others in front of it, giving her tumps up.

They briskly walk past the other objects and leave the hall.

16.10

The family leaves, thanks me for all the help and we agree to speak in the next days/next week.