Non-participation in science A Levels
a longitudinal study of White British working-class students ages 11-16

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Abstract

Patterns of post-16 science participation in the United Kingdom show an under-representation of those from White British working-class backgrounds. Recent research has suggested that while students from these backgrounds may enjoy science, they are significantly more likely than their middle-class peers to see science as 'not for me'. This study draws on 83 longitudinal, semi-structured interviews with twelve White British working-class students and their parents, contextualised against descriptive survey data from the ASPIRES project. Interviews were analysed using a Bourdieusian theoretical framework to explore the role of their out-of-school science engagement in ongoing science participation – this analysis forms the first part of the thesis. Out-of-school factors could not completely account for why students' early interest and engagement in science was not converted into participation of science A levels, thus the remainder of the thesis examines the role of in-school factors – in particular students' choice between Double Science and Triple Science GCSE science awards.

This thesis offers an original theoretical contribution in its exploration of the notions of use-value and exchange-value to understand how different forms of capital are converted by dominant groups into symbolic science-related capital(s), often at the expense of disadvantaged groups who are largely unaware of such conversions. The empirical contribution is a study of White British working-class students' engagement in out-of-school science and an analysis of how the tension between the culture and structures of the science classroom and key characteristics of White British working-class culture can divert students from these backgrounds away from continuing their post-compulsory science studies. The study found the interplay between habitus, capital and field made Triple Science, and subsequently A Level science options, appeared too 'high risk' and represented little use-value for most students, while the few who pursued them produced a habitus distinct from their family background, so science became a viable choice. It is argued that the field of secondary science education presents science as prestigious, abstract and exclusive, resulting in the reproduction of the White British working-class habitus which does not wish to 'rise above its station' and will 'make do' when their aspirations are frustrated, rather than challenge the authority of the school. The result is the majority of students from these backgrounds self-exclude from academic science pathways, regardless of prior enthusiasm or out-of-school engagement in the subject.

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1. White British working-class participation in science – an introduction

1.1. Introduction

In my previous role as a university's science outreach officer, I always felt disheartened during our widening participation (WP) events when teachers arrived with students who were clearly their most well-behaved and high-achieving. They were also, likely, already on track to attend university. As a result, I began to negotiate with teachers to let me know in advance how each student fit our institution's WP criteria. The first time these 'true' WP students arrived on campus they expressed both awe and anxiety as they viewed the grand and slightly intimidating university buildings. The students engaged well with our own student ambassadors and, overall, the programme was considered to be a success. Nevertheless, the short-term nature of the activities made it difficult to derive whether they had any long-term impact for those participants and whether they chose to continue their studies in science at university. I myself have come from a family with little history of higher education, but my experiences attending a grammar school socialised me to develop robust aspirations to attend university, although interestingly not in science – despite high attainment levels. I began to question the viability of our enrichment activities supporting WP students to develop and sustain science aspirations and decided to explore this area further.

This thesis has emerged as a product of my personal background and my professional experiences in public engagement and science outreach. While I am interested in how marginalised groups come to be disengaged with science more generally, my family background made an exploration of the particular experiences of White British working-class (WBWC) youth compelling, particularly given there was very little research in this area. Indeed, amongst the various calls from professional bodies and policy makers to improve the diversity of the science profession, the WBWC are notable for their absence. This PhD, attached to the longitudinal ASPIRES project, provided an opportunity for me to explore WBWC students' engagement and

participation in science in substantial detail, with the aim of improving understanding of how WBWC students come to continue, or not, in post-compulsory science fields.

1.2. The special status of science

Mastery of science has long been considered by educators and policy makers as essential in preparing for modern life (Feinstein, 2011). Indeed, most Western countries' educational policies have prioritised increasing post-compulsory science participation since the 1950s (Lövheim, 2014). Ongoing concerns over shortages in the production of skilled scientists and engineers are reflected in the perennial discourse of 'science in crisis' within media stories and government reports, and the substantial investment given to interventions which seek to resolve this crisis – arguably more so than any other subject discipline (Bøe et al., 2011; DeWitt & Archer, 2015; Smith, 2010b; 2011a).

It is generally agreed amongst policymakers and scholars of science education that a decline in numbers of those studying science has significant economic and cultural implications for any society (Education Standards Analysis Research Division, 2011; Fensham, 1992; Osborne et al., 2003; Smith, 2010b). Indeed, the economic argument has undeniably been the biggest driver behind initiatives and policies to improve science participation rates (Ryder, 2001; Russell Tytler & Osborne, 2012). The UK government consistently highlights the importance of thriving STEM industries for the country's economic success (National Audit Office, 2010; 2018; Parliamentary Office of Science Technology, 2013; G. Roberts, 2002; Turville, 2007), with maths and science subsequently advocated as top priority subjects in schools and amongst the selected 'Strategically Important and Vulnerable Subjects' within Higher Education (Deloitte, 2012; HEFCE, 2011; Prime Minister's Office, 2014).

The crisis discourse has helped to add significant symbolic and market value to obtaining STEM-related higher education degrees, qualifications which already hold an elevated status due to their history of attracting high-attaining students and greater potential for translation into future earnings, consolidating or improving social position and obtaining power and influence (Claussen & Osborne, 2012; Feinstein, 2011; Fitz-Gibbon, 1999; Gorz, 1976; Johnson, 2016; Smith, 2011b; Smith

& White, 2011). The social justice implications of these circumstances have become increasingly salient given the findings of studies showing the vast majority of those continuing to participate in science fields, particularly physical sciences, are traditionally-aged, White, middle-class males (Harding, 1986; Smith, 2010b; WISE, 2014). These findings support claims that racial and ethnic minorities, women and girls, low-income learners, immigrants, and learners with disabilities continue to be under-represented in STEM policies, programmes and practices (Greene et al., 2006).

But what of the White British working classes? WBWC educational underachievement and a supposed poverty of aspirations has been the subject of concern in the realm of public policy in recent years (Demie & Lewis, 2010; House of Commons Education Committee, 2014; Stahl, 2016; The Runnymede Trust, 2009). These discourses are foregrounded against a wider moral panic which positions the WBWC as the 'other' by pathologising them as feckless, deviant and devoid of culture (Reay et al., 2007). Currently there are no studies that focus on WBWC participation in science, however data available in the public realm, such as the HESA Student Record (HESA, 2016), indicate that WBWC students *are* under-represented in post-compulsory science fields. Across three academic intakes (2014-2016), WBWC students made up 15% (±0.5%) of the total undergraduate cohort but constituted only 9.7% (±0.4%) of the total taking science subjects considered to be elite or 'Strategically Important and Vulnerable Subjects', i.e. subjects allied to Medicine and Physical Sciences (HESA, 2016). There is a need for further research in this area, therefore the aim of this thesis was to explore the factors behind WBWC under-representation in post-compulsory science. In light of persistent deficit discourses surrounding the White British working classes, as indicated above, an investigation into the values and cultural dispositions of WBWC students and how this informs their engagement in science was of particular interest.

1.3. Exploring WBWC participation in science – an overview of the thesis

Building from the existing science participation literature discussed in detail in the next chapter, the research outlined in this thesis is an in-depth exploration of WBWC accounts of their experiences in science in an attempt to uncover the mechanisms

which generate their tendency against ongoing science participation, in particular their participation in science subjects at A Level (also referred to in this thesis as 'post-16 science' and 'post-compulsory science'). While I recognise that post-compulsory science education is not limited to A Levels, these more traditional, academic courses are considered to be the gateway qualification to ongoing science participation (DeWitt & Archer, 2015; Smith, 2011a). This is also part of the reason I chose to focus on science participation rather than STEM (Science, Technology, Engineering and Maths) participation. I felt that the particular prestige associated with traditional science fields, as described above, made a focus on improving understanding of unequal WBWC participation in this area more pressing.

Situated within the critical realist paradigm and drawing upon Pierre Bourdieu's social reproduction theory, this study drew from longitudinal interview data, tracking twelve WBWC students and their parents from the last year of primary school (age 10/11) to the last year of compulsory education and training (age 15/16). With these data I was able to explore how WBWC students' accounts regarding out-of-school engagement and views towards ongoing participation in science changed, or were sustained, over time. Furthermore, I could observe how participants' classed, racialised and gendered tendencies towards leisure-time and upbringing more generally were also reflected in how WBWC students conceptualised their navigation of the Triple Science vs. Double Science pathways, considered a key factor in ongoing science participation (*see* Chapter Two) and a significant feature which emerged in the data (*see* Chapter Seven). The intersectional analyses of participants' detailed descriptions were also contextualised against descriptive statistics from ASPIRES project cohort surveys, which provided a broader picture of WBWC engagement and participation in science and afforded some comparison with students from other sociocultural backgrounds.

The findings of this research suggest the narrow, elite and arbitrary view of science, perpetuated through a combination of selective structures, competitive practices and 'exceptionalist' values in school science, is antithetical to many traditional White British working-class cultural ways of being. The findings imply that in order to maintain participation in science, WBWC students must relinquish their (gendered,

classed and racialised) cultural dispositions – such as egalitarianism and wariness of risk – in order to 'fit in' and succeed in the field of formal science. Participants in this study (for a number of reasons) were often unable, or unwilling, to do so once they reached adolescence. Consequently, most participants opted out of continuing their science studies, even those who had the prior attainment which would normally give them access to do so. The novel contribution to knowledge of this thesis, therefore, is the provision of empirical data detailing how key White British working-class values act as a mechanism to inform WBWC students' engagement with science. In addition, this thesis also contributes an understanding of how the high exchange-rate of White middle-class masculine cultural resources, expressed through the values and structures of formal science, acts as a mechanism to limit the ongoing science participation by WBWC students, suggesting a shift from deficit explanations of non-participation and a more critical view of the culture of school science should be developed in order to make it more inclusive to those from marginalised groups.

The thesis consists of eight chapters, beginning with this introductory chapter, which has contextualised the study and provided an overview of the thesis. **Chapter Two** outlines the two most common discourses used to explain and discuss under-representation in science, the 'leaky pipeline' and the 'diversity argument'. This is followed by a review of the literature exploring the relationship between a student's family background and science participation, to identify possible generative mechanisms resulting in the under-representation of WBWC students in post-compulsory science. The chapter ends with an introduction of the three research questions which emerged from the literature and to which the research in this thesis responds.

Chapter Three is dedicated to outlining the theoretical approach I took in the study, drawing upon Pierre Bourdieu's concepts of habitus, capital and field, which he used to explain social reproduction. I expand on how Bourdieu's ideas have been used in previous research on science participation (including the wider ASPIRES project), and explain why I felt his concepts, augmented by intersectional theory and situated within the Critical Realist paradigm, were useful tools to explore the marginalisation of certain groups within formal science fields.

Chapter Four provides a detailed account of the methodological strategy taken to explore the research questions posed at the end of Chapter Two. I outline the philosophical assumptions I made when considering the phenomena under study, including my ontological, epistemological and axiological positions. This is followed with an explanation of how these views informed my research design and choice of methods, and how these were situated within the wider ASPIRES project of which this research was part. The research participants are then described, including details of how they were sampled and how social class was conceptualised. The chapter concludes with details on the ethical research practices undertaken, arguments as to the validity and reliability of the data collected, and a description of the analytic process undertaken.

Chapters Five, **Six** and **Seven** lay out the findings of the research, with Chapters Five and Six dedicated to outlining the changing nature of participants' *out-of-school* engagement with science over time, while Chapter Seven – due to features emerging from the data – focusses on the nature of participants' *in-school* choice between two different pathways of GCSE science. **Chapter Five** discusses interview participants' accounts of early out-of-school engagement with science from primary school, contextualised against data from the large-scale ASPIRES cohort survey. Using a Bourdieusian-inspired framework to categorise activities depending on how strongly they align with dominant ideas about science, I argue that WBWC participants' early out-of-school engagement in science was widespread and varied, with many of their activities strongly associated with dominant scientific culture. Furthermore, I explain how the theoretical framework served to identify classed and racialised approaches to child-rearing within the student and parent interview data and discuss the influences this may have on their future science participation.

Chapter Six explores participants' engagement in out-of-school science in secondary school, again contextualised against ASPIRES cohort survey data. I discuss participants' diminishing engagement with science and present a Bourdieusian and intersectional analysis of students' habitual behaviours regarding activities done during their free time. I argue that participants' classed, gendered and racialised tendencies towards leisure-time activities become more pronounced as they grow

older, while their parents further withdraw from using their authority to direct students' choices. At the end of the chapter I compare the dispositions of students who did and didn't maintain engagement in activities associated with dominant scientific culture. I argue that those who did maintain their engagement displayed dispositions more commonly associated with White, middle-class masculinity and actively distanced themselves from activities and practices typically associated with White British working-class culture. I end the chapter with a final discussion of the implications for participants' engagement in out-of-school science for their ongoing science participation.

In **Chapter Seven**, I focus on participants' choice of science award at GCSE and explore how this may be related to their ongoing science participation, once again contextualised against ASPIRES student cohort survey data. The chapter outlines participants' rationales for their choice, analysing their accounts using Bourdieu's theories to unpack the role of social class in their decisions. The analysis reveals how students and their parents reproduced discourses generated from the school to 'nudge' certain students into particular pathways. I then argue that these discourses, along with selective practices and structures particular to school science, contributed towards a (re)production of classed, gendered and racialised tendencies which culminated in most WBWC students choosing to opt out of the higher status Triple Science and, eventually, out of post-compulsory science courses.

Finally, in **Chapter Eight**, I draw together the findings of the three data chapters along with wider literature to outline the key empirical and theoretical contributions of the thesis. This is followed by a discussion of the limitations and implications of the study, and thoughts regarding possible directions for future research.

2. Understanding social differences in student science participation

2.1. Introduction

Chapter One outlined how ongoing concerns regarding a diminishing science workforce have helped to raise the status of science and suggested this had social justice implications for groups marginalised in science, such as the White British working classes (WBWC). This second chapter reviews the literature more specifically to discuss key features related to post-compulsory science participation. As indicated in the previous chapter, WBWC students have been associated in policy discourse with educational underachievement and a 'poverty of aspirations'. Within policy spheres these barriers to educational success are often strongly linked to WBWC students' family backgrounds, particularly a lack of parental engagement in their child's schooling (Demie & Lewis, 2010; Stahl, 2016). As such, I was particularly interested in science participation literature which focussed on the influence of out-of-school factors on science aspirations and attainment in science. My non-deficit approach to this study of WBWC participation in science also led me to studies exploring the culture of the science classroom and how a student's sociocultural background informed their development of a 'science identity' which aligned with that culture.

As there is limited research on WBWC participation in science, the chapter particularly considers studies which explore the role of social class – as well as race and gender – on differential science participation and extrapolates implications for WBWC students by drawing on literature on their participation in education more generally. The chapter concludes with the research questions which emerged from the literature and formed the basis of this study. First, the chapter takes a closer examination of the two main discourses surrounding the issue of science participation, in order to contextualise the literature discussed later.

2.2. Discourses around improving science participation

There is a general consensus amongst educators, scholars and policymakers that studying science is important, but where viewpoints diverge is *why* it is important, and for *whom*. In order to begin examining why WBWC students are under-represented in post-compulsory science fields one must account for their position within the two main, conflicting discourses which surround improving science participation: one 'reversing the diminishing pool of highly skilled and talented school and university graduates', the other 'challenging the exclusive and arbitrary nature of canonical scientific culture'. The former is the one most commonly used to justify many policies and initiatives aimed at improving science participation and will be discussed first.

2.2.1. The science pipeline – 'leaking' or 'diverting' WBWC students from science?

The metaphor of the 'leaky' science pipeline is often used in policy literature to mean the issue of high-achieving, trained individuals leaving science at different career stages and is framed as a major obstacle to the UK's competitiveness and prosperity (The Royal Society, 2014). Most of the literature in this area focuses on attrition at the stages between compulsory education and further or higher education, with the 'leaks' conceived as happening due to factors within the school environment (e.g. Broughton, 2013; Department for Business Energy and Industrial Strategy, 2018; National Audit Office, 2010; Turville, 2007). The metaphor of a 'leaking pipeline' suggests that science participation levels can be improved by 'plugging' standalone problems; as with the metaphor of 'barriers' to science participation, this can be criticised for neglecting to address wider institutional and societal factors which may have greater influence (Ametller & Ryder, 2015; Cleaves, 2005; Gorard & See, 2009; Homer & Ryder, 2015). Indeed, there has been considerable criticism of this perspective of the 'problem' of science participation and its use of the pipeline metaphor.

The 'leaky pipeline' has proven to be a popular image amongst policymakers in particular and has led to a number of initiatives and policies which aimed to address the problem, such as attracting science graduates into teaching, increasing the

science content within the National Curriculum and other curriculum reforms (Smith, 2011a). However, some academic scholars have questioned their rationale, suggesting the discourse around the science recruitment problem is accepted too readily and raising questions as to whether there is really a crisis in the first place (Osborne & Dillon, 2008; Smith, 2010a). A further noted omission within this discourse is a critical discussion of why pathways to science have multiple exit points but only one entry point (Adamuti Trache & Andres, 2008). As Osborne & Dillon (2008) note, this places a unique responsibility on school science education to provide future scientists – a burden not shared with any other curriculum subject. Furthermore, foregrounding an *academic* science pipeline fails to recognise the potential for vocational pathways into science, which studies suggest are more likely to be taken up by working-class youth (L. Archer, DeWitt, Osborne, et al., 2013; Goyette & Mullen, 2006; Homer et al., 2014).

The narrow focus of the science pipeline also has repercussions for the wider student cohort. Many scholars have pointed to the tension between a science education which aims to provide training for future scientists and to educate future citizens (Millar & Osborne, 1998; D. A. Roberts, 2007; Ryder & Banner, 2011). The science pipeline features heavily in science literacy debates and is criticised for dominating the school science curriculum – at the expense of enabling all students to critically engage in science issues outside of the laboratory context (Claussen & Osborne, 2012; DeBoer, 2000; Osborne & Dillon, 2008). Research suggests interest in science increases when students are able to make connections between the scientific concepts they learn at school and the activities they do at home, as they are able to view the concepts as connected to their 'everyday experiences' (Tran, 2011); this conceptualisation of scientific literacy is argued to be essential in order for individuals to engage in socioscientific debates, to be enriched culturally and to be effective citizens (Cossons, 1993; Feinstein, 2011; Millar & Osborne, 1998; Reiss, 2007). As White working-class students have been found to be more engaged with an applied science curriculum (*see above*), an academic, pipeline-focussed curriculum may lead to WBWC disengagement in science in the social realm, as well as the science classroom (Mendick et al., 2017b).

These shortcomings resonate with another major source of criticism levelled at the pipeline model: how it deals with the loss of women, low-income and ethnic minorities at every educational transition (Calabrese Barton et al., 2008). Lack of diversity within the leaky pipeline literature is often framed as a 'loss of talent' for the science workforce (Campaign for Science Engineering, 2008; The Royal Society, 2014), with gender, social class and ethnicity presented in reports as 'personal' factors (BIS, 2011) to be considered on an individual – rather than structural – level. Within science education research this perspective has been accused of misrecognising how school science can be used as a filter to screen out students from marginalised social groups and attributing higher status and power to those who remain (Aikenhead, 1996; Clark Blickenstaff, 2006; Fensham, 1992). It is possible that, despite not specifically addressing the 'leak' of individuals from WBWC backgrounds, the pipeline literature would present the issue similarly as a 'loss of talent'. Nevertheless, the as-of-yet complete lack of consideration of WBWC individuals within the science pipeline discourse does invite the question of whether they are considered 'talented enough' or whether their absence would be explained by the similarly persistent discourse of White working-class educational underachievement and poverty of aspirations (Gillborn, 2009; 2010; House of Commons Education Committee, 2014; Reay, 2009; Stahl, 2012; 2016).

Criticism of the pipeline model has coincided with increasing calls for the participation crisis discourse to shift from increasing the numbers of those who choose science subjects to changing the nature of science institutions themselves to enable them to retain qualified and interested individuals from *all* backgrounds (Adamuti Trache & Andres, 2008). This alternative discourse is discussed in the next section.

2.2.2. The diversity argument and 'the problem with science'

Challenging assumptions about the ways of doing and thinking about science has been undertaken by feminist scholars since the 1980s (Allegrini, 2015). Evelyn Fox Keller, one of the prominent voices at this time, claimed that if more women were to participate in science then science itself might change, and that such an idea clashes

with a value-free view of science "determined by its own logic and empirical methodology" (Keller, 1985, p.76). The radical science movement re-conceived science as a social process which expresses the world-view of the dominant class or culture (Benton & Craib, 2011). Scholars in the field began to see science as a human activity, and to explicitly consider how scientific knowledge is constructed and accepted (Aguilar & Krasny, 2011; Hodson, 1992; Lemke, 2001; O'Loughlin, 1992).

Sociocultural approaches to formal science education research emerged from the work of feminist scholars, which took the view that teaching and learning science is historically and culturally situated, with students bringing their own perspectives and subjectivities when constructing understanding (Aikenhead, 1996). They argued that it is essential to acknowledge the effect of a learner's sociocultural background in order to realise pupil achievement and sustained participation in science (Jegede & Aikenhead, 1999; O'Loughlin, 1992). Scholars exploring diversity issues in science participation claim that sociocultural approaches help us to unpick the specific culture of school science and the implications of this culture for marginalised youth who may not feel they are legitimate participants in formal science education (L. Archer et al., 2012a; B. A. Brown, 2004; Calabrese Barton, Tan et al., 2008; Clark Blickenstaff, 2006). WBWC disengagement from education more generally has been the focus of a number of studies, particularly White working-class boys (Ingram, 2011; Reay, 2006; 2009; Stahl, 2012; Willis, 1977). It is possible the science classroom represents a particularly acute experience of disaffection for WBWC students.

As might be expected, studies looking at factors related to science participation range in their explanations relative to their position within the discourses outlined above. The literature reviewed here largely falls under the sociocultural, feminist literature situated within the *diversity* discourse, as I believe this provides a more critical and socially-just perspective to explore the marginalisation of WBWC youth in science on a systemic level. Nevertheless, I have also included some studies which describe the association between individual, 'personal' features and science participation in order to contextualise my discussion of the former body of literature. The following review is thus organised into three sections: educational achievement in science, science aspirations and science identity, although there is some overlap. Each section

describes the nature of the association between the feature and science participation, followed by a discussion of literature which considers the role of family background – in particular social class – in this association. While these studies do not appear to explicitly fall in the realm of critical realism, their analyses nevertheless suggest potential mechanisms which may have some pertinence for WBWC participation in science.

2.3. Educational achievement in science

Academic achievement has consistently been suggested to have a strong relationship with science persistence (Basu & Calabrese Barton, 2007; DeWitt & Archer, 2015; Gorard & See, 2009; Homer, Ryder et al., 2014; Mau, 2003). In particular, attainment and self-efficacy have been shown to be linked and are considered to contribute towards students' ideas regarding the likelihood of success in pursuing science in future (Bøe & Henriksen, 2015). Research suggests that students tend to perceive science as difficult (Gorard & See, 2008; Lyons, 2006; Osborne, Simon et al., 2003) and it has been found to be one of the hardest marked school subjects, particularly at A Level (Coe et al., 2008; Croxford, 2006; Fitz-Gibbon, 1999). Thus, it is possible that students are likely to be put off from studying science at A Level, unless they have sufficiently high enough attainment to suggest they are going to be successful. While this argument hasn't yet been used specifically used to explain WBWC under-representation in post-16 science, the wider discourse of educational underachievement and the White working classes (Demie & Lewis, 2010; House of Commons Education Committee, 2014) suggests that it is worth considering as a feature here.

At first glance this argument appears to present a sound logic, but there are some issues which problematise its consideration as a mechanism in this research. Firstly, it does not account for evidence showing girls and other marginalised youth not choosing to study science at A Level even when they have the requisite prior attainment, and secondly, the relative difficulty of science subjects at A Level is taken for granted. This section explores these issues in further detail.

2.3.1. Science for the 'top' people

As indicated above, the assumption that prior attainment in science equals future potential in science study is problematic, as intrinsic ability is not something that can easily be measured, if at all (van de Werfhorst et al., 2003). Furthermore, Gorard and See (2008; 2009) have questioned why prior attainment should be so crucial to the study of science. They argue that ongoing participation in science, if it is not considered in absolute terms as participation to the point of being a scientist, should not be contingent on prior attainment. In other words, increasing post-16 science participation has the benefit of improving the general scientific literacy of all students and not just those who will continue to be future scientists.

Nevertheless, studies have shown that structures and practices exist within schools to maintain the special status of science as 'only for the few'. For example, there is evidence that schools constrain access to post-16 science qualifications based on how students did in that subject in the past, while access to other subjects is less restricted (L. Archer, 2013; Gorard & See, 2008; van de Werfhorst, Sullivan et al., 2003). Furthermore, science is the only school subject in the UK with more than one stream at GCSE level (*see also* sub-section 2.3.2.2). The main two are the more traditionally academic courses: *Combined Sciences* or the 'Double Science' award as it is more commonly known, provides two science GCSEs; *Single Sciences* or 'Triple Science' awards three GCSEs in the separate science subjects of Biology, Chemistry and Physics (L. Archer, Moote, et al., 2016b).

While Double Science is officially presented as a sufficient award for students intending to take science at A Level (Fairbrother & Dillon, 2007; Millar, 2011; National Audit Office, 2010; SCORE, 2011), Triple Science is extolled by industry as the best preparation for A Level study and considered the preferred science qualification by university admissions tutors (CBI, 2008; 2009; Gorard & See, 2009). However, like science A Levels, access to Triple Science is restricted based on prior attainment (Archer, Moote et al., 2016b). Indeed, the relationship between Triple Science and ongoing science participation is so strong (Broughton, 2013; Education Standards Analysis Research Division, 2011; Homer & Ryder, 2015; Homer, Ryder et al., 2014; National Audit Office, 2010; Parliamentary Office of Science Technology, 2013), it is

arguable that the point when students choose, or are placed in, the Double Science or Triple Science streams is the point when they tend to take their path towards, or away from, post-compulsory science participation.

These factors all contribute towards the association with science being an inherently 'difficult' subject that is 'only for the best'. For some students, the perceived difficulty of science gives it a special status with high risk and big rewards; meanwhile, other students are dissuaded from continuing their future studies because the potential risk of failure compared to other subjects is considered too high (Gorard & See, 2008; 2009; Kahneman, 2000; Mendick et al., 2017a; Osborne, Simon et al., 2003). Students from low socioeconomic status (SES) families have been argued to be particularly susceptible to concerns regarding the risk of taking difficult subjects, even when they have the requisite prior attainment to continue (Codiroli, 2015; Gorard & See, 2008; 2009).

Croxford (2006) suggests female and working-class pupils lack confidence in their ability relative to their peers and are most susceptible to stereotyping in adolescence - which is when they are making key choices about post-compulsory education i.e. science participation. She implies that this explains why such students are more likely to choose subjects or qualifications with the reputation for being easier. Self-esteem has indeed been argued to be tied to educational achievement (The Runnymede Trust, 2009), and it has been suggested that WBWC students particularly tend to suffer from poor self-confidence in (middle-class) educational environments where they face a high-risk of failure (Demie & Lewis, 2010; Reay, 2009). Science appears to present a particularly risky educational field, thus WBWC student self-confidence is of interest in this study. This will be explored further in section 2.5.

Social class is considered to be the strongest predictor of educational achievement in the UK (Kerr & Dyson, 2014; Kerr & West, 2010; National Equality Panel, 2010; B. L. Perry et al., 2012; Reay, 2016), and several studies looking at determinants of science participation have found that prior attainment in science is stratified by SES, to the point where it has been proposed that prior attainment effectively acts as a proxy for social class (Gorard & See, 2008; Homer et al., 2011; van de Werfhorst, Sullivan et al., 2003). The authors of these studies refute essentialist, meritocratic conclusions that

students from middle-class backgrounds are simply better at science; instead they tend to point to the influence of opportunities afforded from being brought up in a more advantaged environment, including access to resources which support educational achievement. These issues are explored further in the next sub-section.

2.3.2. How does family background explain differential science attainment?

Sociological researchers in the wider field of education have suggested a number of background factors to explain the educational achievement of middle-class students. These include living in better areas with better schools, having the choice of private schooling and tutoring, being pushed by parents to engage in school-like activities in their leisure time, parental experience and agency to navigate school systems and choice – all things which they argue make it harder for advantaged youth to fail than it is for disadvantaged youth to succeed (Bottero, 2009; Crozier et al., 2011; Iannelli, 2013; Lareau, 2011). Meanwhile, there is evidence that certain Minority Ethnic (e.g. Indian and Bangladeshi) students from disadvantaged backgrounds are more like to engage in home-learning experiences which support educational achievement than White British working-class students (Siraj Blatchford, 2010). Indeed, research has shown working-class parents do not tend to organise their child's leisure time, instead choosing to keep the child and adult spheres separate (Lareau, 2011).

It has been suggested that parenting practices and home learning in early years can strongly predict ongoing educational participation, while parents' involvement in school becomes more prominent in later years (Strand, 2012). This sub-section explores how these factors specifically figure in science attainment, to explore the implications for WBWC students.

2.3.2.1. Getting a head start in science

The findings regarding classed and racialised parental support as presented above can arguably be directly transferred to realising educational achievement in science. There are, however, a number of studies which have explored the relationship between home learning practices and science attainment. For example, research with White middle-class 'high-ability' participants found that they had early histories of engagement in science-related experiences which developed dispositions

considered to be 'better suited' to the pursuit of achievement in science, such as outgoing, risk-taking exploratory behaviour (Joyce & Farenga, 1999). The study also suggested that such early engagement was more likely to lead to an established interest in science before it is encountered as a formal course in schools, resulting in 'adaptive academic behaviours' which are subsequently mediated by *perceptions* of their ability, rather than *actual* past performance in science. Interestingly, such activities were found to be more likely to be undertaken by boys than girls; it was proposed this may be the result of socialisation processes where young girls are encouraged to conform to 'compliant' rather than 'exploratory' styles of behaviour. This resonates with a body of research exploring student 'science identity', which is explored further in section 2.5.

Another common practice amongst middle-class families is the private consumption of 'cold' scientific knowledge found in objects such as reference books or documentaries, which has been argued to be close in nature to the formal science learning found in schools and (L. Archer et al., 2010; Ball & Vincent, 1998). Furthermore, reading widely is suggested to make students more familiar with the range of academic language used extensively – but often taken for granted – in the science classroom, thereby facilitating students' comprehension of new scientific concepts (Snow, 2010). Lyons (2006) suggests that parents' use of scientific discourse at home can also benefit their children in their education, if it fits with the attitudes and language of teachers. Talking about science at home and providing science-related resources which may support a child's attainment in school science are practices which have been found to be particularly common amongst middle-class parents who work in STEM-related jobs or who hold STEM qualifications (L. Archer et al., 2012b; DeWitt & Archer, 2015).

The additional support middle-class students enjoy extends to freedom from financial restrictions on their spare time. Aschbacher et al. (2010) found what they termed as 'low-achieving persisters' initially aimed to persist in their science-related studies despite low grades, but by the end of high school had either chosen to leave formal education entirely or shift their aspirations to non-academic science-related courses e.g. nursing, in community college or trade school. Aschbacher and

colleagues suggest that this may have been due to the negative experiences these students had in school science, although other social factors may have also played a part. For example, these students – predominantly low-income females – were more likely to have an after-school job than their high-achieving counterparts, and their jobs e.g. waitress usually didn't support the development of academic skills. This left them little time or energy to access extra-curricular science-related activities or tackle high-level science courses in the manner of their high-achieving peers. The implication is that the restrictions placed on them by having to provide additional income constrained their opportunities to invest in their educational achievement, resulting in them voluntarily withdrawing from academic science routes.

2.3.2.2. *Widening the attainment gap – stratification practices in the science classroom*

The advantages these outside factors bring for middle-class students can be amplified by structures within school; one of the more controversial practices is the setting of children according to ability, which has been found to only marginally benefit high attainers but have a significantly negative impact on low attainers (Francis, Connolly, et al., 2017). The practice of attainment grouping is considered to be biased against working-class youth, who are disproportionately represented in the bottom sets or 'streams' and argued to promote social segregation (Francis, Archer, et al., 2017). Indeed, teachers' perceptions of students' abilities have been found to be influenced by their social class, meaning disadvantaged students are less likely to secure access to the higher-level sets and, once they are in within these lower sets, they are subject to practices which are said to constrain rather than develop their educational achievement (Ball, 1984; Francis, Connolly et al., 2017; Iannelli, 2013). In such situations, working-class youth can become quickly demotivated (L. Archer et al., 2007b), internalising their low placement as a lack of ability rather than as representing their current attainment levels (Francis, Connolly et al., 2017). In view of the relative difficulty of science and the record of WBWC educational underachievement it seems likely that WBWC students will tend to be placed in the lower science sets, limiting their chances of future educational success in science.

The existence of more than one GCSE science pathway raises similar concerns. Providing multiple pathways to science is usually proposed as a 'egalitarian' solution but has been found to – in actuality – create a stratification of attainment (Croxford, 2006), which we know to be strongly correlated with social class. E. Perry & Francis (2010) contend that the existence of multiple science awards is, in effect, a streaming practice which, as discussed above, is a system biased against children from poor backgrounds who are statistically less likely to perform as well as their counterparts from more affluent families. In the ASPIRES project, Archer, Moote et al. (2016b) found evidence that the streaming of students into Double or Triple Science routes has led to stratification practices by class and ethnicity, with working-class students and particular Minority Ethnic students more likely to be streamed into Double Science. They argue that Triple Science acts to reproduce social inequalities by filtering out students from those backgrounds from ongoing science participation and highlight how the use of differential science pathways reinforces the discourse of science being an 'elite' subject for 'clever' people.

Furthermore, despite the general consensus regarding the relationship between Triple Science and ongoing science participation, access to this science pathway is not universal. The award is less likely to be available in areas of higher deprivation and in non-selective, state-maintained schools (Gorard & See, 2008). Schools serving deprived communities are also more likely to have structures which do not accommodate Triple Science within the normal school timetable and outside of GCSE options, placing constraints on disadvantaged students which are usually not applicable to their more privileged peers (Fairbrother & Dillon, 2009; Millar, 2011; OPSN, 2015; The Sutton Trust, 2015). Recent research shows that, compared with other pupils, pupils from more deprived backgrounds achieve relatively larger improvements in their future A-level science and maths outcomes when offered Triple Science at GCSE than when offered only combined science (National Audit Office, 2010). Regardless, it has been suggested that non-selective state schools and those serving deprived areas may prioritise 'less demanding' courses, such as Double Science, in order to improve students' chances of getting better grades, perhaps due to the influence of school and college performance tables (Engineering UK, 2015).

Meanwhile, when schools do offer Triple Science they largely reserve the award for the most able students (Bennett & Lubben, 2013; Cox, 2015; Francis, Archer, Moote, DeWitt, MacLeod, et al., 2016) although rules on student eligibility vary considerably (Archer, Moote et al., 2016b; Fairbrother & Dillon, 2009).

Overall, there is evidence that highly-able young people from deprived communities are less likely to take the Triple Science route than their more advantaged peers (The Sutton Trust, 2015). While some of this may be accounted for by lack of access, there are suggestions that even when accounting for prior attainment, disadvantaged students are less likely to opt to take Triple Science due to concerns of not being 'clever enough' (Archer, Moote et al., 2016b). In addition, the ASPIRES project found evidence of middle-class students being strongly influenced by their parents to take Triple Science due to its transferability into science at A Levels (*see* sub-section 2.4.2.), while working-class students appeared to be less well-informed about the advantages of taking the Triple Science and many came to regret taking Double Science once these became apparent (Archer, Moote et al., 2016b).

The association between WBWC students, social disadvantage and academic underachievement suggests WBWC students are less likely to be located in schools which offer Triple Science. Furthermore, if it is available to students it is unlikely to be so on a universal, unrestricted basis. The strong relationship between Triple Science and ongoing science participation invites further exploration of whether WBWC students have a choice to take Triple Science, and if so, whether their family background influences how they make that choice.

Evidence that, even when accounting for prior science attainment, working-class students do not tend to take Triple Science or continue to post-compulsory science study and, furthermore, are disadvantageously placed to follow these pathways, indicates that 'educational achievement' and 'Triple Science uptake' are not suitable *generative mechanism* candidates for exploration in this study. However, the strong relationship between attainment and social class has rendered educational achievement as a *significant feature*, within the broader picture of WBWC under-representation at science A Level. Indeed, it has highlighted many of the actions and strategies taken by middle-class parents and certain Minority Ethnic parents to

facilitate their child's educational success in science; including engaging them in out-of-school activities which increase their confidence in the science classroom and pushing them to take Triple Science as their GCSE science qualification. Far less is known about what working-class parents do, or do not do, to facilitate their child's attainment in science. As parents from WBWC backgrounds are frequently positioned in public and political discourse as being disinterested in their child's education (Stahl, 2016), this area is considered worth further exploration as a potential mechanism in the under-representation of WBWC students in science A Levels.

2.4. Science aspirations – an interest in science or science as a means to an end?

Given the current focus on school science education for future science careers (*see* sub-section 2.2.1), it is perhaps unsurprising that one of the biggest areas of attention in science participation research is students' science aspirations. Establishing early science aspirations is frequently cited as important for student persistence in the area, with some suggesting this can compensate for other factors which may dissuade students from future participation (Cleaves, 2005; Gorard & See, 2009; Maltese & Education, 2011; Maltese & Tai, 2010; Tai et al., 2006). A survey of science and engineering practitioners conducted on behalf of the Royal Society found nearly two-thirds (63%) of respondents reported having considered a career in STEM before the age of 14. Of those respondents, nearly half (28%) formed these ideas before the age of 11 (The Royal Society, 2004).

On the other hand, some scholars have challenged the claim that the majority of students who continue to study post-compulsory science make their decision early in their school career, arguing that choice is a dynamic, ongoing process rather than a rational decision made at a specific time (Ametller & Ryder, 2015; Homer & Ryder, 2015). The longitudinal ASPIRES project has explored the relationship between students' science aspirations and their later science participation, finding that a number of sociocultural factors shape whether and how young people develop science aspirations (L. Archer, 2013; L. Archer, DeWitt & Wong, 2013; DeWitt & Archer, 2015). What they and other researchers in this area agree on is that a student's family background can have a profound influence on the development of

their science aspirations (Aschbacher, Li et al., 2010; DeWitt et al., 2013; Gilmartin et al., 2006; Gokpinar & Reiss, 2016; Mujtaba & Reiss, 2013).

As already mentioned, the White British working classes have been a particular target of the 'poverty of aspirations' discourse (Demie & Lewis, 2010; House of Commons Education Committee, 2014; Siraj Blatchford, 2010; Stahl, 2016; The Runnymede Trust, 2009) and therefore exploring the literature around the sociocultural mechanisms informing science aspirations was considered to be an important component of this review. This section presents two different perspectives to developing science aspirations which emerged from this literature: 'enjoying science' and the 'strategic value of science'; and discusses what these mean for the wider picture of WBWC students' under-representation in post-16 science.

2.4.1. Enjoyment and interest in science

Having an intrinsic interest in and enjoyment of science is generally considered to be strongly connected to an individual's likelihood of developing science aspirations and persisting in STEM fields (Baram-Tsabari & Yarden, 2009; Chiu, 2010; Dabney et al., 2012; Maltese & Education, 2011; Maltese & Tai, 2010; Naizer, 1993). Against a backdrop of concerns regarding the negative effects of a 'dull' and 'decontextualised' school science education (Bøe, Henriksen et al., 2011; Lyons, 2007; Murphy & Whitelegg, 2006; Osborne, Simon et al., 2003), studies have suggested that engagement in out-of-school science activities has a strong relationship with developing an interest in science (L. Archer, DeWitt et al., 2010; Fenichel et al., 2010; Joyce & Farenga, 1999; Lin & Schunn, 2016; Stocklmayer et al., 2010). While the more precise nature of this relationship is less well known, L. Archer, DeWitt & Wong (2013) suggest that taking part in science-related hobbies and extra-curricular activities on a *long-term* basis may shape science aspirations, but this depends on the nature of the activities being meaningful and personally involving.

One such type of out-of-school activity is play. Play has been suggested to be an integral part of learning science at all levels of education (Andrée & Lager-Nyqvist, 2012; Hasse, 2002). Thirty years ago, Henniger (1987) noted that the use of play in science and mathematics fosters a child's natural curiosity, enhances divergent

thinking and increases motivation to learn because the child is in greater control over the nature of the activities. Play was one of three essential aspects of Woolnough and Allsop's (1985) model for science learning: play, practice and exploring. Play was 'practical experiences to build a feel for the phenomena and an interest in the area' (Woolnough & Allsop, 1985, p.49). More recently, play has been advocated as a way for children to create imaginary scenarios where their ideas about science and scientists can be acted out (Andrée & Lager-Nyqvist, 2012). The unstructured nature of science play, which is not reliant on specific tools or resources, makes it a democratic activity, accessible to all. Furthermore, as Henniger (1987) consistently stressed in his work, science play benefits from being a low-risk activity for children to engage in, due to the decreased chance of a them experiencing failure or 'incorrect responses'. The ASPIRES project (L. Archer, DeWitt et al., 2010) found evidence of primary-aged students engaging in similar informal, fun activities at home but while they suggested such activities to be valuable in their own right, most participants who talked about their science engagement in this way did not aspire to become a scientist. In contrast, the few students who did speak of wanting to be a scientist tended to engage in more formal science activities, such as reading reference books and using science kits – and were more likely to be from middle-class families.

Research measuring the effects of students' participation in structured science activities is known to be difficult, although it is somewhat easier than unstructured activities such as science play and 'tinkering' (Dabney, Tai et al., 2012; Jensen, 2015). A number of benefits have been cited for taking part in more structured science activities (such as museum visits, science clubs and science competitions). In particular: improved learning outcomes, more 'authentic' science experiences, access to positive role models and the provision of STEM career information (Jensen, 2015; Luehmann, 2009; Tran, 2011). Taking part in science/STEM clubs and competition has been particularly highlighted as associated with an increased likelihood of continuing with science (Dabney, Tai et al., 2012; Woolnough, 1994). Equally, in their longitudinal study Gottfried & Williams (2013) found that, overall, there was a statistically significant association between regularly attending a STEM club and both an increase in school science attainment and subsequent choice of a

STEM course at university. However, the association disappeared for disadvantaged youth, regardless of race. They suggested that students affected by poverty may face additional restraints, such as after-school employment or family obligations, meaning they are unable to attend as frequently as their advantaged peers and recommended further research into the area.

There are arguments that restrictions on out-of-school science engagement faced by working-class youth extend beyond the immediate obstacles suggested by Gottfried & Williams (2013). Kowalczyk et al. (2015) suggest that working-class experiences of being constrained by economic pressures has led them to develop a 'taste for the necessary', while the middle classes are insulated from such pressures, giving them a sense of ease and leading them "to favour activities that lack immediate function, a tendency which simultaneously serves as a marker of their social distinction" (p.62). They suggest that this explains a tendency for the working classes to be 'impatient' with abstract thought and anything which lacks 'immediate and evident function'. This resonates with Roe's (1953) classic study of (White, male and mostly middle-class) scientists, where she found that the home background was described as important, with the habit of learning for its own sake particularly significant. It is possible that working-class parents are less likely to see the long-term value of their children engaging in science activities associated with abstract knowledge, although it less clear what sorts of activities they would prefer.

Meanwhile, findings from the ASPIRES project suggests it is less an issue of what science-related activities working-class parents prefer their children to engage in, as to whether they involve themselves at all. As indicated in sub-section 2.3.2., research has shown that parental approaches to leisure time is largely classed and racialised, with working-class parents more likely to leave their children to manage their own time to achieve the 'accomplishment of natural growth', while middle-class parents engage in practices of 'concerted cultivation', which aim to develop their child's interests into formal 'talents' through participation in structured activities (Lareau, 2011). Drawing on Lareau's ideas, L. Archer, DeWitt et al. (2012b) found evidence that White working-class participants who expressed enthusiasm about science tended not to be supported formally by their parents to engage in science activities,

nor was science embedded within family life – practices more commonly found amongst White and South Asian middle-class families. Nevertheless, while the evidence suggests that White middle-class and South Asian families are more likely to develop science aspirations at an early age, there is a potential for students with overly organised home schedules to experience 'science fatigue', which Lin & Schunn (2016) suggest may adversely affect their overall science interests and motivation in science.

As Ryder et al. (2015) explain, when students' choices are said to be based on a 'personal interest' in science, the interests are dynamically situated in social contexts. The findings described in this section do indeed complicate the relationship between increasing student interest and enjoyment in science to develop science aspirations, and therefore facilitate ongoing science participation. They suggest that WBWC students are not necessarily less likely to be interested in science, but they are less likely to be supported by their parents to develop their science interests into something more permanent and recognisable as a 'talent', instead leaving their interests – as L. Archer, DeWitt et al. (2012b) term it – 'raw' and 'unrefined'.

2.4.2. Seeing the value of science to realise aspirations

A strong utility motivation towards science uptake i.e. whether subjects would facilitate the achievement of educational or career aspirations, has been found to be a significant influence on the development of science aspirations, and is considered equally, if not more important than intrinsic interest in a subject (Holmegaard et al., 2015; Mujtaba & Reiss, 2013; 2016; Wang & Staver, 2001). Indeed, extrinsic motivation has been suggested to allow students to overcome diminishing intrinsic interest based on pedagogical style or curriculum content (Cleaves, 2005; Lyons, 2007).

Mujtaba & Reiss (2013) found students who reported receiving advice from parents and/or teachers on the extrinsic material gain of taking physics were more likely to aspire to continue post-compulsory physics. Parents are considered to be both a source of information on school-related choices and a big influence in making such choices (Bender, 1994; Gorard & See, 2008; Homer & Ryder, 2015). Furthermore, the

quality of a student's relationship with their parents has been identified as a strong influence on science enrolment decisions, with indicators of 'socioemotional investment' experienced through support, encouragement, trust and respect (Lyons, 2006).

However, several studies evidencing the existence of social inequalities in the uptake of post-compulsory science discuss the possibility of differential family support in science choices and the development of science aspirations based on a student's sociocultural background. Parents with higher occupational or educational status and parents from Minority Ethnic (particularly Asian) backgrounds tend to have high educational aspirations for their children and the high status of science careers means they are more likely to dispose their children towards ongoing science participation (Adamuti Trache & Andres, 2008; L. Archer & DeWitt, 2015; Codiroli, 2015; DeWitt et al., 2011; Lyons, 2006). There is evidence that parents from these backgrounds express their advocacy of science through the provision of science-related materials such as books, magazines and science kits and through shared participation in out-of-school science activities (L. Archer, DeWitt et al., 2012b; Lyons, 2006; Mujtaba et al., 2018). In contrast, studies suggest that low-income families may be less likely to enthusiastically encourage their children to learn about science or provide guidance which would lead to the uptake of science subjects (Aschbacher, Li et al., 2010; B. L. Perry, Link et al., 2012).

The suggested classed and racialised differences in families' promotion of science may be explainable by the distinction between the autonomy warranted from the 'accomplishment of natural growth' and the frequent interventions arising from 'concerted cultivation' (Lareau, 2011) (*see above*). However, a point made by Lyons (2006) suggests another factor may also be involved. He proposes that the intrinsic/extrinsic dichotomy of reasons for choosing science subjects suggests that some students are orientated on the basis of future benefit, while others are more considerate of the present. This is similar to the earlier point of the working classes tending to be focussed more on the immediate benefits of participation in activities (Kowalczyk, Sayer et al., 2015), suggesting they are less likely to be interested in, or aware of the extrinsic value of science. Indeed, a study by Mujtaba, Sheldrake et al.

(2018) found participants with low socioeconomic status (SES) were less likely to perceive science as having utility in their future lives and inferred this may constrain such students' science aspirations. Thus, WBWC families may tend to have little faith in the abstract nature of a future, *possible* advantage brought about by pursuing science, particularly given the higher risk of failure presented by science fields (*see* sub-section 2.3.1.).

As with science attainment, the science aspirations of WBWC students were not considered to be a generative mechanism in this study. However, as a feature science aspirations points to the classed and racialised practices used by families to steer their children towards science, or to leave them to make up their own minds. Existing clues suggest WBWC parents may not tend to be interested in engaging in science at home, either for personal interest or as a strategy for developing their child's interests in future science participation. This hypothesis invites further investigation, including what this means for WBWC choices in and about science.

2.5. Science identity and a clash of cultures

Science identity theory has emerged in recent years to provide an alternative approach to understanding differential science participation. Looking beyond issues such as prior attainment – which fails to explain why high-achieving students from marginalised groups tend not to take post-compulsory science (*see* section 2.4) – theorists of science identity are interested in why certain types of student 'fit' in the science classroom, while others seem to be 'misfits' (R. Tytler, 2014). This work has developed from researchers exploring the range of differences between students' cultural identities and the culture of the science classroom in order to address the needs of students who may feel alienated by school science (Costa, 1995).

The model initially advanced by Costa (1995), and later built on by Aikenhead (1996); (2001), conceptualised the 'successful' learning of science as a crossing of cultural borders from students' life-world subcultures (e.g. family background, relationships with peers) to the subculture of school science. Learning science was presented as a process of socialisation whereby students are transformed into members of a scientific community, familiar with standards of explanation, particular modes of

discourse and 'canonical problem niches' (Hawkins & Pea, 1987). For students whose home and social cultures are congruent with the cultures of school and science, the crossing is 'smooth', other students find the crossing 'manageable' but for students whose home culture is discordant with school science, this border-crossing can be 'virtually impossible' (Aikenhead, 1996; 2001; Aikenhead & Jegede, 1999).

While this view of science identity has been criticised for dealing with identity as 'static' and 'self-imposed' (Carlone et al., 2008) rather than "both situationally emergent and potentially enduring over time and context" (Carlone & Johnson, 2007, p.1192), the work provides a useful lens for examining the nature of school science and raises the question: whose cultural identity *does* it represent? This section explores these ideas in further detail, discussing how some students are able to negotiate a science identity which is recognisable in the science classroom while others are not, and what this means for WBWC students and their ongoing science participation.

2.5.1. What is the culture of the science classroom?

As described above, science learning has been argued to be a process of familiarisation with 'canonical science'. More particularly, this has been suggested to be the type of science taught in school science but not necessarily directly useable in everyday life and is often considered as a 'pure', abstract body of incontestable, authoritative knowledge (Claussen & Osborne, 2012; O'Loughlin, 1992; Snow, 2010; P. Thomson, 2005; Upadhyay, 2010). Some scholars have argued that this is in order to maintain a high status and level of difficulty – imbuing scientific knowledge with both power and exclusivity (Aikenhead, 2003; Gonsalves et al., 2013; Hughes, 2001) (*see* sub-section 2.4.1.).

Claussen & Osborne (2012) suggest that students whose 'border-crossing' into school science is the smoothest are more likely to accept facts from an authority, be intrinsically motivated, have the agency to take risks, and have the means to wait for potential future rewards. As discussed earlier in this chapter, courting risk and having the resources to wait for future rewards are features not normally associated with working-class students. Furthermore, there is evidence that, rather than tending to

accept facts from an authority, White working-class culture typically attributes value to knowledge derived from known community members with first-hand experience or built collectively and physically with ones' hands and muscles (Luttrell, 1989). Other features of Western school science culture highlighted in the literature are that it is exclusive, competitive and often aggressive (Adamuti Trache & Andres, 2008; Calabrese Barton & Tan, 2009; Carlone & Johnson, 2007; Lemke, 2001), traits which do not generally align with the egalitarian values White working-class students have been found to display in education more widely (Stahl, 2016).

The implication is that students who are easily encultured into science are those most likely to continue their science studies, while those who encounter difficulties in this process are likely to drift away from science. The common conclusion of studies looking at cultural difference in science is that the culture of school science is characterised by White, masculine, middle-class values, and that these features are 'taken for granted' in a way which leads to the marginalisation of youth who do not share these characteristics and a delegitimisation of their culture (Aikenhead, 1996; Bøe, Henriksen et al., 2011; Costa, 1995; Jegede & Aikenhead, 1999; Lemke, 2001; O'Loughlin, 1992; Tan & Calabrese Barton, 2010). It appears that WBWC students would be likely to fall into the group of students whose culture is not recognised in the science classroom, with profound consequences for the likelihood of them continuing with their science studies. This idea is explored further in the next sub-section, which details literature exploring how gender, race and class interact to shape science identities in the classroom.

2.5.2. The 'ideal', the 'unconventional' and the 'wrong' science student

Several studies using an identity approach have observed school-level factors significantly affecting the development of students' science identities (Brickhouse & Potter, 2001; Buck et al., 2009; Calabrese Barton, Tan et al., 2008; Furman & Calabrese Barton, 2006). While they recognise that the diversities of students' science identities make meeting the individual needs of students complicated, nevertheless it is suggested that teachers and schools have a responsibility to help students retain an identity that is desirable in their home community which is also recognisable in the science classroom. However, many studies have found evidence

of the contrary, where teachers and/or school structures disrupted or misrecognised 'unconventional' science identities. When participants in the Aschbacher, Li et al. (2010) study questioned the norms and values of school science – for example the reliance on textbooks and the use of overly academic language – they also reported feeling teachers saw them as 'deficient'.

The majority of identity studies in science participation have focussed on the effect of gender in establishing recognised science identities. Brickhouse et al. (2000) suggested that science teachers continue to hold gendered stereotypes within the classroom, which serve to exaggerate the differences between girls and boys. They found this extended to the point that girls with science identities which did not fall into the predictable stereotype – obedient and diligent – were rendered invisible in the science classroom; they were assumed to be 'not good at science'. They give the example of a participant who was not considered particularly well-behaved by the teachers but expressed an intrinsic interest in science and required challenge in her classes to keep her motivated. Nevertheless, she was placed into a middle-track/set science class and this appeared to affect her intrinsic interest to the extent the authors felt it was unlikely she would continue participating in science (Brickhouse, Lowery et al., 2000) (*see also* sub-section 2.4.2.2).

The ASPIRES project found that girls were more likely to lack confidence in their science identities and perceive others do not see them as 'science people', especially if they identified with key aspects of popular femininity such as being 'girly' and 'sporty' (L. Archer, Dawson, et al., 2015; L. Archer & DeWitt, 2015; L. Archer, DeWitt et al., 2012a; L. Archer, DeWitt, Osborne et al., 2013). Calabrese Barton, Tan et al. (2008) believe this to be symptomatic of the limited power girls have in the science classroom, citing how girls are less likely to be called upon to answer content questions and given less attention by science teachers than boys. Boys, meanwhile, are more likely than girls to be seen by teachers to have a 'natural talent' for science – even when accounting for attainment, or despite having comparatively *lower* attainment than their female peers (Carlone, 2004; Clark Blickenstaff, 2006).

These practices are all said to have profound implications for girls' ongoing participation in science. Brickhouse et al. (Brickhouse, Lowery et al., 2000) suggest

that the girls encouraged by their teachers and schools to study science in the short-term are more likely to be the ones who see participating in science as part of performing a 'good student' identity, rather than those with an intrinsic interest in science; the likelihood of such girls participating in science on a long-term basis is, therefore, uncertain. Interestingly, Carlone et al. (2015) found evidence amongst their study on boys' ongoing science participation that intrinsic interest in science mattered less than seeing oneself and being recognised by others as a 'smart science student'. While these findings point to issues with youth's negative experiences in the science classroom (and the issue of the intrinsic/extrinsic dichotomy – *see above*), it is notable that the boys' identity still appeared to maintain a facet of science, while the girls' identity was implied to be wholly academic.

Class and race often interact with gender as dynamic variables to complicate the development of students' science identities (Carlone & Johnson, 2007). Students with an established science identity are argued to more likely be male, middle-class students from White or Asian backgrounds (L. Archer, DeWitt, et al., 2015; L. Archer, DeWitt, Osborne et al., 2013; Aschbacher, Li et al., 2010). This aligns with discourses linking science and scientists with an intellectual form of masculinity normally associated with the middle classes (Ingram & Waller, 2014). L. Archer, E. Dawson, A. Seakins, J. DeWitt, et al. (2016) argue such discourses can lead some boys to display confident, arrogant and sometimes aggressive displays of scientific knowledge which marginalise girls and non-dominant boys. As a result, the students most likely to be hindered in the development of a science identity are suggested to be White and Black working-class girls who perform sexualised heterofemininity in school; they are often perceived by schools and teachers as 'not academic' and not inhabiting the 'appropriate body' for science (L. Archer, DeWitt et al., 2012a; Francis, Archer, Moote, DeWitt, MacLeod et al., 2016). Black working-class girls are argued to be particularly vulnerable, due to the multiple inequalities they face (L. Archer, 2013; L. Archer, DeWitt et al., 2015).

Some identity research has sought to problematise essentialist notions of gender in relation to the male dominance of science and the science classroom. For example, it has been argued that the close association between science and middle-class,

'academic masculinity' (consisting of 'muscular intellect' and 'behavioural compliance') can also put off working-class boys; especially if they perform popular, hegemonic 'laddish' forms of masculinity (L. Archer, Dawson, Seakins, DeWitt et al., 2016; L. Archer, DeWitt & Willis, 2013). In Furman & Calabrese Barton (2006) study, they saw that a boy who wanted to remain 'cool' developed a science identity which was not 'sciencey' but generally knowledgeable and capable in science. Black & Hernandez-Martinez (2016) found in their study that even privileged White male students struggled with reconciling a 'sociable' disposition and identifying with being 'brainy'. Carlone, Webb et al. (2015) submit that such examples serve to challenge 'monolithic' views of the successful male science student, and particularly highlight the role of social class in boys' performances of a science identity and the smoothness of their trajectories in school science. They found the boys within the study who were from privileged backgrounds exhibited broader, more adaptable and resilient scientific and social identities which facilitated their educational success and ongoing participation in school science.

This reflexivity and flexibility of middle-class males' identity formation has been observed in broader educational studies, which also found working-class students tend to have difficulty negotiating complementary educational and social identities – to the extent many express concerns about losing their cultural identity as a result of educational success (Ingram, 2011; Ingram & Waller, 2014; Reay, 2001a). O'Loughlin (1992) discusses research by Heath (1983), who observed that students from White working-class backgrounds found their own sociocultural and experiential interpretative frameworks were negated in the science classroom; and suggests the only way for these students to achieve educational success was to abandon their frameworks and "begin to function effectively in the abstract, decontextualised canon" recognised in school science (O'Loughlin, 1992, p.815). The seeming disparity between the cultural identity most recognised in the science classroom (White, middle-class masculinity) and the cultural characteristics of the White British working classes discussed above implies that WBWC students, particularly females, may be more rigid in maintaining their cultural identity, which in turn prevents them from developing their own 'viable' science identity in other science contexts.

2.5.3. 'Forming into' and 'shifting from' science identities

As indicated earlier, the bulk of science identity research takes an approach that identity is something which is not fixed but shifts over time and place and is profoundly influenced by whether or not it is recognised by others (Carlone & Johnson, 2007). The 'ideal' science identity has been argued to be a construction formed by classed, gendered and racialised values, and evidence has shown that families from middle-class backgrounds in particular attempt to transmit these values to their children through a range of practices. Aschbacher, Li et al. (2010) in their U.S. study found that student participants from different social backgrounds had different experiences with science in and outside of school, including extra-curricular activities and role models within the extended family network. They concluded that middle-class and Asian American students tended to be supported by family members to participate in science in multiple communities, receive tutoring, and be mentored by family role models working in science or science-related fields. These students were more likely to consolidate their science identities and persist in science and science-related aspirations.

In the UK, the ASPIRES project had similar findings related to the investment and support of South Asian families in establishing academic science identities in their children as part of a cultural discourse which positions science and science careers as 'respectable' (L. Archer, DeWitt et al., 2012b). As discussed in section 2.4. they also found evidence that White British middle-class families often capitalised on their child's interest in science by holistically embedding science into family life with practices such as regular conversations about science, collective watching of science programmes on TV and engagement in science-related extra-curricular activities closely resembling canonical science. The authors assert that this relationship with science can play a substantial role in making science "known, thinkable, desirable, and achievable" (L. Archer, DeWitt et al., 2012b, p.894). Meanwhile, they suggest that WBWC students tended to pursue science interests individually, and as such their interest was defined as 'raw' and 'unrefined' (L. Archer, DeWitt et al., 2012b). In other words, the children from White middle-class families and South Asian

families were more likely to develop robust science identities compared to those from White working-class families.

The body of science identity research discussed here presents some serious implications for the ongoing science participation of marginalised youth. The positioning of White, masculine, middle-class ways of doing science as 'superior' or 'natural' suggests non-confirming students must actively develop corresponding dispositions in order to maintain their participation; often at a personal, cultural cost. Those who are unable, or unwilling, to develop a 'recognised' science identity have been found to (voluntarily) withdraw from formal science programmes when science ceases to be compulsory (B. A. Brown, 2004; Claussen & Osborne, 2012). The 'unable' likely shift their identities to communities of practice where they are recognised and where they can envisage a future career (Aschbacher, Li et al., 2010). The 'unwilling' are suggested to be amongst those students who do not see post-compulsory science courses as an attractive platform for them to develop and realise themselves and their interests in science (Holmegaard et al., 2012). Whether WBWC students tend to be unable or unwilling remains yet to be explored.

2.6. Summary and research questions

This literature review chapter has drawn on studies which apply a critical sociocultural and feminist lens to explore key features considered to be associated with ongoing science participation. Prevailing deficit discourses surrounding WBWC students, such as educational underachievement, as well as the pathologising of WBWC parents as disinterested in their child's education, led me to focus on literature exploring the role of a student's family background in their ongoing science participation. In particular, I discussed studies investigating how a student's sociocultural background can influence their educational attainment in science, their science aspirations and the development of viable science identities. Although there is limited research focussing specifically on White (British) working-class students, the intersectional approaches of many of the studies discussed here allowed for some extrapolation of the implications for WBWC students, with the use of wider educational literature.

Based on the literature explored here, one can conclude that WBWC students are likely to be amongst those students who are more constrained by gendered and racialised stereotypes in the science classroom, and that the traits normally associated with those who 'fit in' with the culture of school science do not appear to correspond with many values and practices exhibited by WBWC students in education more generally. These points suggest that WBWC students are less likely to develop a science identity which is recognised in both the science classroom and in their home/community environment, although further research is required to test this hypothesis and its viability as a mechanism generating WBWC under-representation in ongoing science participation.

The absence of consideration of WBWC students within the science pipeline discourse does imply that they are amongst those whose under-representation from post-compulsory science is explained by them being 'inadequate learners' (Basu & Calabrese Barton, 2007) (*see also* sub-section 2.3.2). The deficit view of WBWC youth has been unpicked in wider educational literature, but the strong association between educational achievement and science participation does invite further study of WBWC students' science attainment and their science persistence, especially what, if any, practices WBWC parents undertake to facilitate their child's achievement in science. Furthermore, given that the choice of Triple Science is a strong determinant of science A Level take-up, an exploration of whether or not WBWC students are more likely to take Double or Triple Science and how they view such choices would be of value.

Engagement in extra-curricular science activities is a recurring theme throughout the science participation literature presented here, identified as a key practice middle-class parents use to support their child's educational achievement, the development of science aspirations and consolidating an identity which sees science as 'for me'. Working-class families were argued to be less likely to invest in such practices, but little is known about the nature of WBWC engagement in out-of-school science. Considering the popular and political discourse which presents WBWC parents as disinterested in their child's education, it serves as an empirical and social justice contribution to explore this area further.

Many of the issues discussed above could be argued to be transposable to other sociocultural groups who are marginalised in science. Nevertheless, as seen in this chapter, much of the sociocultural science participation literature has explored aspects of their experiences already. There is a lack of empirical research which undertakes a detailed investigation of the potential mechanisms involved in the under-representation of WBWC students in post-compulsory science fields, including exploring how certain identified characteristics of WBWC culture may act to disengage WBWC students within the science classroom. This thesis aims to address some of these gaps with the following questions:

1. What is the nature of WBWC youth engagement in out-of-school science, and how does it change over time?
2. What, if any, is the relationship between out-of-school science engagement and WBWC students' participation in science A Levels?
3. What are the possible mechanisms influencing WBWC students' choice between Double Science or Triple Science pathways, and in what ways may this choice affect their ongoing science participation?

The next chapter presents the theoretical resources this study drew from in order to respond to these research questions.

3. Bourdieusian perspectives to science participation

3.1. Introduction

Based on a review of the relevant sociocultural literature, I suggested in the previous chapter that certain cultural and structural features of school science may act to reproduce social class inequalities in science participation – inequalities which are often complicated by gender and ethnicity. This thesis seeks to shed further light on the mechanisms which contribute towards WBWC underrepresentation in post-compulsory science, using the theoretical resources which are outlined in this chapter.

The theoretical framework this study has used is based upon the social reproduction theory of Pierre Bourdieu and scholars who have adapted and extended his ideas in the field of education and science education. In this chapter I present Bourdieu's three main concepts of *capital*, *habitus* and *field* (Bourdieu, 1977b; 1990; 2010), discussing how they have already been used to explain social inequalities, particularly of social class, in science participation literature and their usefulness in my own study. I then discuss the limitations of Bourdieu's work and follow this with an outline of some theoretical responses to these limitations as developed by other scholars in the field. I begin the chapter with an examination of the notion of 'social class' and the different ways it is conceptualised in science participation studies.

3.2. Conceptualising social class

As seen in the previous chapter, a student's social class has been argued to play a significant role in the likelihood of them continuing with science once it ceases to be a compulsory subject. But how is social class defined? Do science participation studies agree on a definition? This section explores these questions in more detail and discusses the conceptualisation of class used in this thesis.

3.2.1. What is social class?

Social stratification has existed in most societies since ancient times and the concept of social strata, or 'social class', is largely considered to be one of the enduring concepts of sociology in the UK (Crompton, 2008; Waters, 1991). Nevertheless, while most sociologists can agree on the importance of social class theory, conceptualising class has proven to be hugely contentious (Bottero, 2009). 'Social class' as a term can have meaning as a description of material inequalities, social prestige or as an indication of income group or occupation (Devine & Savage, 1999; Hout et al., 1993; Weber, 1946; 2010).

In the UK, class associations are often bound up with status and distinctions of inferiority and superiority (Devine & Savage, 2005). Towards the end of the 20th Century, to speak of class differences became taboo, represented as a 'fault of the nation' – something backward and antiquated (Skeggs, 2005a). During this time the term 'working-class' was replaced within popular and political discourses with euphemisms such as 'inner city' or 'hard-working families', often as a way to distinguish the virtuous from the feckless 'underclass' (Reay, 1998; The Runnymede Trust, 2009). In more recent years, the term 'working-class' has made a reappearance as part of the discourse on White working-class underachievement, but still with deficit associations (*see* Chapter Two).

Academic discourse has found the concept of social class to be equally 'slippery' (Bottero, 2009; Crompton, 2008). While some social class theorists conceptualise social class as an abstract range of fixed class categories (Peterson, 1992; Rose & Pevalin, 2005; Savage et al., 2013), others treat class as complex and dynamic (Lareau, 2000; Reay & Ball, 1997; Skeggs, 2004a). It can be treated as a reflection of economic and social status (Goldthorpe & McKnight, 2004; Weber, 2010) or as borne out in everyday practices and processes, social and cultural experiences (Ball, 2003; Reay, 2006). The next sub-section discusses the most common measures of social class in educational literature, in order to be aware of the strengths and limitations of the claims authors make regarding social class differences in science participation.

3.2.2. Common measures of social class in science participation literature

As indicated above, the controversial associations with terms such as 'social class' and 'working-class' has resulted in their infrequent use in literature on science participation. Indeed, it is much more common to see the term socioeconomic status (SES), although, as we will see, the inconsistency in defining SES has been argued to make identifying patterns of participation by social class more difficult (Gorard & See, 2008).

When studies comparing social difference in educational outcomes use the terms working-class or socioeconomic status, they are most frequently referring to social disadvantage or economic deprivation, using proxies such as number of students entitled to Free School Meals (FSM), or Income Deprivation Affecting Children Index (IDACI) (Gillborn, 2009; House of Commons Education Committee, 2014). FSM, the more common indicator of the two, has attracted significant criticism as a measure of social class, with concerns about both reliability and validity (Hobbs & Vignoles, 2007). Particular issues include whether the indicator used is eligibility or actual uptake of FSM, or if there are pupils who are legally eligible but not known about. There are questions regarding lack of clarity behind the choice of variables from which the FSM is constructed, which are argued to be in danger of producing tautology in analysis. Finally – and crucially for social class – is the indicator's binary focus on the extremes of poverty (Boaler et al., 2011; Gorard & See, 2009). The IDACI, as a scale, is argued to be a more comprehensive measure, however the variables it is constructed from, such as postal address, are still open to challenges of validity (Boaler, Altendorff et al., 2011).

Another common measure of social class is the Office for National Statistics' Socio-economic Classification, or NS-SEC, originally developed by John Goldthorpe in the 1990s. Goldthorpe's ideas were in the tradition of Max Weber, who saw class as a reflection of similar shared life chances, represented by economic resources such as wealth and opportunities of income and one's social position (Weber, 2010). The NS-SEC schema endeavoured to be an 'objective' classification tool based on skill and prestige that neatly aggregated occupational groups into class categories (Devine & Savage, 2005; Holton & Turner, 1994). An individual's profession was seen as a

reasonable measure for social class because it purported to reflect their educational attainment, wealth and status; factors that are often considered as useful measures of social class themselves (Warde & Gayo-Cal, 2009). The current NS-SEC has seventeen categories, which can be collapsed into eight analytic variables. Of the eight categories, categories 6 'Semi-routine occupations' and 7 'Routine Occupations' (with 8 being 'never worked and long-term unemployed') are considered by Goldthorpe to be equivalent to working-class occupations (Goldthorpe & McKnight, 2004; 2006).

Goldthorpe himself has stated the case for measuring social class in economic terms, claiming that class positions are derived from social relations in economic life, specifically employment relations (Goldthorpe & McKnight, 2006). Like Weber, Goldthorpe has asserted that in addition to the prestige attached to greater financial resources, on a more pragmatic level the middle classes can buy better food, better housing, better healthcare and a more privileged education, all factors that then contribute towards social advantage and an increased likelihood of reproducing advantage for future generations (Goldthorpe, 1996; Weber, 2010).

However, the NS-SEC has also attracted considerable criticism. Feminist scholars have argued that occupationally-based schema, normally derived from the male individual of a household, does not reflect the participation of women in work and therefore could not be considered as gender-neutral. They claim that, as a result, women's social class becomes mediated by their relationships with men (Crompton, 2008; Reay, 1998). Others have argued that a precise and measured economic approach to the meaning of class is reductive and devoid of theory (Bottero, 2004; Pahl, 1993).

The appeal of fixed categories based on relatively easily acquired, scalable data, is that it is easy to operationalise and has a reasonable level of internal reliability. The objections discussed above, however, raise questions as to the validity of such social class measures. Many have argued that reducing social class to an economic measure obscures the cultural and social associations tied up with class (Devine & Savage, 2005; Savage, Devine et al., 2013; Skeggs, 2004a). Scholars with this

perspective have turned to other sociological sources in order to conceptualise a measure which adequately reflects the multiple, interacting facets of social class.

Theorists of the recent 'cultural turn' reconceived class as made and attributed value through culture, where class is "deployed both as a resource and as a form of property, working through categorisations of race, gender, nationality and sexuality" (Reay, 2006, p.290). Operationalising this conceptualisation of class has proved to be less straightforward, however, and some studies have opted to use occupational schema as part of the participant sampling process, followed by a more fluid approach to class in the analysis (e.g. Reay, Davies, et al., 2001; Reay, Hollingworth et al., 2007). Other studies, including several on science participation (e.g. Anderhag et al., 2013; DeWitt, Osborne et al., 2013; Strand, 2012), have considered a social class measure incorporating culture that is based on the level of parental *education*. As will be discussed below, parental education is often used as a measure of 'cultural capital', one of the theoretical constructs Pierre Bourdieu used to explain the role of education in the reproduction of social inequalities (Bourdieu, 1977a). The rationale for using parental educational level is that the longer one is exposed to the formal education system, the more cultural capital one is likely to acquire and hence the higher the social class (Warde & Gayo-Cal, 2009). Thus, in these studies, university graduates are usually considered to be middle-class while those who leave formal education before university tend to be considered as working-class.

3.2.3. Conceptualising 'White British working-class' in this thesis

The first part of this chapter has sought to introduce the complexity and inconsistency of 'social class' both as a theoretical concept and as a variable in empirical research. This sub-section aims to clarify the epistemological position on social class taken in this thesis, and thus what is meant by 'White British working-class'.

The 'White British' of WBWC are usually considered within educational literature to be an ethnic group, denoting a demographic with shared historical, social and cultural

ties that are 'native' to Great Britain[1] (Haralambos et al., 2013; Stahl, 2012). This understanding of 'White British' is seemingly uncontested in literature related to educational achievement and participation, to the extent that it is rare to find an explanation or definition accompanying its use. The 'British' aspect of WBWC is a central characteristic, as the 'Any Other White' group in demographic data can include White Irish, Gypsy/Roma and White European ethnicities – so-called *non-native* sociocultural groups (Office for National Statistics, 2012); although 'non-native' in itself is a problematic term that resonates with racist rhetoric (Rogaly & Taylor, 2009; Tolia-Kelly, 2008). Nevertheless, despite claims of careful distinction between 'White' and 'White British', the term 'White British working-class' is often used interchangeably with 'White working-class' (*see* House of Commons Education Committee, 2014; Stokes et al., 2015). This thesis uses 'White British working-classes' both to recognise the particular UK context within which this study operates, and to avoid the marginalisation of those from minority ethnic backgrounds that occurs when White working-classes is conflated with *British* working-classes (Rogaly & Taylor, 2009). Furthermore, I use the plural of 'classes' to acknowledge the heterogeneity of White British working-class*ness* (Maguire, 2005; The Runnymede Trust, 2009; Travers, 2017).

As has been discussed in the previous chapters, and will be outlined further in Chapter Four, social justice underpins the rationale and the methodology of this study. The 'normative' conceptualisation of the middle-class experience and the 'spoiling' of the White working-class identity has led to class dis-identification, argued to be itself a classed process (Bottero, 2004; Reay, 1998; Reay & Ball, 1997; Savage et al., 2001; Skeggs, 1997). Indeed, it is sometimes joked that the only individuals who would now claim to be working-class are academics who, by virtue of being university-educated and their occupational status, would usually be considered as having 'crossed over' to the middle classes (Maguire, 2005; Wakeling, 2016). In

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[1] According to the Office for National Statistics (2012). *Ethnicity and National Identity in England and Wales 2011*. (London: Office for National Statistics)., the 'White British' census tick box is labelled as 'White English/Welsh/Scottish/Northern Irish/British'

recognition of this stigmatisation of the WBWC and with a wish to redress it, I take a non-deficit approach to class in this thesis.

To clarify further; economic-based measures of social class have always positioned working-class groups at the bottom end of a social hierarchy – regardless of claims to the contrary (Rose & Pevalin, 2005). With this – and the aforementioned wider limitations associated with such indicators – in mind, my position on social class is not a purely economic one. Nevertheless, I take a similar view to Skeggs (1997) that class can be manifested as exclusion and deprivation, and economic wealth remains a dynamic factor in these processes. In her study of White (British) working-class females, participants were "never in a position to disregard money" (Skeggs, 1997, p.81), unlike, Skeggs argues, those from middle-class backgrounds. Chapter Four outlines further how I have considered economic wealth as a factor in participant's social class both as part of the sampling process, and in the data analysis.

It is my view that a non-deficit conceptualisation of social class, while acknowledging the inequitable distribution of financial wealth, should recognise and attribute symbolic value to White British working-class cultural values and practices. This is not in order to 're-valorise' White working-class culture at the expense of (White) middle-class culture (Reay, 2001a), but to achieve greater parity *between* social classes (Reay, 2013). Thus, the position I take on social class in this thesis is that class operates dynamically as cultural expressions, practices and values, but is often enacted as a form of exclusion and denigration in order to protect the interests of those in power. In the words of Skeggs (2004a): "Class formation is dynamic, produced through conflict and fought out at the level of symbolic" (p.5). This approach to social class enables me to scrutinise exclusionary, 'othering' practices realised in formal science education – such as those discussed in Chapter Two – while also recognising the value of WBWC approaches to scientific practice and the knowledge it produces. The theoretical framework I have used to do this draws from Bourdieusian theories of social reproduction, which are outlined in the remainder of this chapter.

3.3. Bourdieu and the reproduction of social inequalities

As has been stated, 'social class' has been conceptualised in a range of different ways, having evolved from largely economic positions to also reflect the importance of culture. French sociologist Pierre Bourdieu was a significant contributor to the changing in meaning of 'class', with his research on social and cultural reproduction further developing the importance of status and the dynamics of power in social class theory. Bourdieu believed that the social hierarchy is reproduced because agents situated within it use particular strategies to maintain and consolidate their position of dominance (Bourdieu, 1990). These strategies utilise the cultural resources agents possess and present them in such a way as to appear natural and innate. As a result, their status of privilege is secured and this in itself is rendered as part of the status quo (Bourdieu, 1986). These processes act as a way to distinguish such groups from others in the social spectrum and who, as a result, are excluded and deemed illegitimate.

In his writings, Bourdieu introduced the theory that the reproduction of class inequalities was a result of the interplay between the three elements he termed forms of symbolic capital (economic, social and cultural), habitus (dispositions) and field (context) (Bourdieu, 1977b; 1990; 2010). It was his position that the interaction of these three elements was predicated on systems of exchange and that the system was weighted in favour of those in positions of power. Bourdieu presented the relationship between his conceptual trinity as the following formula: *(Habitus x Capital) + Field = Practice* (Bourdieu, 2010 p. 95). As this is presented, it is arguable that Bourdieu did not intend for the three concepts to be considered in isolation from one another. Nevertheless, capital, specifically cultural capital, is the Bourdieusian idea most commonly used in science participation literature (e.g. Adamuti Trache & Andres, 2008; Claussen & Osborne, 2012; Lyons, 2006). The following sub-section presents Bourdieu's conceptualisation of the different forms of capital, with particular attention to cultural capital, and how they have contributed towards analyses of social difference in science participation.

3.3.1. Capital

Rather than focussing merely on the dynamics of economic 'capital', Bourdieu was concerned with the mode of cultural production and re-production, which creates and then privileges what he called 'symbolic' capital (Nash, 1990). Symbolic capital comes in various forms and 'makes the games of society', but Bourdieu cautions us as to assume that these games are based on perfect competition or perfect equality of opportunity. Instead, capital, in all its forms, is accumulated over time. It has the ability to sustain itself through reproduction and has the power to inscribe itself in things in apparent objectivity, when the resulting reality is that opportunity is not at all equal (Bourdieu, 1986).

Bourdieu declared that society is structured based on how forms of capital are distributed in the social world. The social structure experienced by various social groups arises from the unequal distribution of capital and functions to determine their life chances through the constraints and opportunities it generates. Bourdieu claimed that those at the top of the class hierarchy are able to maintain their position because symbolic capital is transferred across generations through cultural reproduction, using appropriate structures that have been developed for this purpose by the dominant groups themselves (Bourdieu, 1986). In his 1986 essay *The Forms of Capital*, Bourdieu identified three forms of symbolic capital: economic capital, cultural capital and social capital. He conceived economic capital as related to monetary wealth and property ownership (Bourdieu, 1986), while cultural capital and social capital were conceptualised in a more complex manner. As such, cultural and social capital will be outlined here in greater depth, while economic capital will be discussed in relation to both concepts.

3.3.1.1. Cultural capital

'Cultural capital' is the product of accumulated labour devoted to acquiring (dominant) cultural knowledge and artefacts (Bourdieu, 1986). According to Bourdieu (1986), there are three states of cultural capital: *objectified* as cultural goods, *embodied* as a disposition, or *institutionalised* in the form of educational qualifications. Thus, cultural capital is not an inherent aspect of the social agent but

is *acquired* after birth. One of the ways families can support the appropriation of cultural capital is to 'transmit' some of their own capital to the child by exposing them to the relevant objectified and institutionalised cultural capital. The greater amount of cultural capital held by a family, the easier and quicker it is to begin these practices of *cultural transmission* (Bourdieu, 1986). Those with the most cultural capital can begin earlier and dedicate more time to it, prioritising cultural transmission over other activities that would have to be enacted at an alternative occasion. Visits to science museums, science festivals and other related events are all typical practices in this vein. Bourdieu states that as the transmission of cultural capital has social rather than economic conditions it is therefore less overt and the most hidden form of capital transmission. This concealment renders it symbolic, with the outward appearance of genuine competence rather than acquired capital (Bourdieu, 1986).

Cultural goods, in a relatively straightforward manner, can be obtained in their *objectified* state via economic means and symbolic means. They can be found in the form of pictures, books, machines, etc. and are consumed and accumulated just as one would any other material goods (Crook, 1997). Thus, as discussed in Chapter Two, a common practice of middle-class parents wishing to 'capitalise' on their child's interest in science is the accumulation of science-related equipment such as telescopes and microscopes, or science magazines and books (L. Archer, DeWitt et al., 2012b). By consuming these objectified forms of dominant *science-related* cultural capital – cultural capital strongly associated with canonical science – a child may become more familiar with dominant aspects of scientific culture and be well positioned within the science classroom to increase their cultural capital further (Claussen & Osborne, 2012; Lyons, 2006).

On the other hand, one cannot purchase or be gifted *embodied* capital; instead it is obtained within the physical and mental limits of the bearer and dies with them (Bourdieu, 1986). The process of embodiment is the result of internalising external objectified goods as a disposition, which is then reflected in the bearer's personality and inclinations through their accent, manner and attitude (Bourdieu, 2010; Crozier, Reay et al., 2011). That which has been embodied in the social agent is then manifested externally as a seemingly natural and innate characteristic. In the case of

science, the practice of accumulating science-related goods can only be fully appreciated and leveraged if one has also internalised aspects of scientific culture as scientific *dispositions* (Claussen & Osborne, 2012). Chapter Two outlined some recognised scientific dispositions such as the use of abstract, academic language to talk about scientific ideas and the acceptance of scientific knowledge from institutional authorities; dispositions arguably associated with the middle classes.

Bourdieu reasoned that the acquirement of embodied cultural capital demands a significant amount of time and investment on the part of the social agent, as in order to be authentic it has to be done first-hand. As such, the most effective way of accruing cultural capital is for it to commence at the same time as an individual's socialisation and therefore the influence and input of the family is significant (Bourdieu, 1986). The family wishing to cultivate an inclination for science in their child will actively give them science-related objects and items from an early age to establish a 'naturalness' interacting with such objects. L. Archer, DeWitt et al. (2012b) saw this as a common practice amongst middle-class families who enacted what Lareau (2003) calls 'concerted cultivation'. Crozier, Reay et al. (2011) state concerted cultivation is a way for middle-class parents to invest in 'high culture' for their children, often to compensate for the perceived inadequacies of their child's school. As suggested earlier, the 'high culture' of science is argued to be canonical scientific knowledge and practices that are recognised in the science classroom and can be leveraged for educational achievement.

Bourdieu claims that the *institutionalised* state of cultural capital, such as in the case of education qualifications, is a form of objectified cultural capital that needs to be considered separately from other cultural goods (Bourdieu, 1986). Academic qualifications are both objectified and embodied cultural capital, the latter being the case because they are 'biologically' limited to the bearer. Academic qualifications are valuable because they represent the cultural competence of the holder in a constant and legal way and by objectifying cultural capital as academic capital one can hide or 'neutralise' its embodied properties (Bourdieu, 1986). The Triple Science award GCSE is perceived by many to hold the ultimate status of scientific competence in compulsory secondary education, despite assertions by the government that the

double award is also an adequate measure (*see* Chapter Two). Likewise, A Levels in the natural sciences – in the form of biology, chemistry and physics – are seen as the 'gold standard' for entry to study science subjects at university, while other less academic qualifications, such as BTECs, hold lower value.

The role of cultural capital in educational inequalities within science

Of all Bourdieu's forms of capital, cultural capital was the most fully conceptualised in his writing. This is no surprise, given the prominence of the finding presented in his seminal 1984 book *Distinction* on the association between an individual's social position and their preference for 'legitimate' areas of culture (Bourdieu, 2010; Warde & Gayo-Cal, 2009). Bourdieu considered examples of legitimate areas of *objectified* cultural capital to be classical painting and music, their legitimacy being assured through their sanctioning by cultural critics. Meanwhile, the 'popular' taste attributed to artworks and music Bourdieu claimed had no pretension or artistic ambition was mostly associated with the working-class members of the study and had a negative correlation with educational attainment (Bourdieu, 2010). Although Bourdieu limited his framing of culture to the arts, leisure activities and aesthetic preferences, there is a strong argument to extend cultural capital to incorporate science and technology due to their increasing importance in contemporary life (L. Archer, Dawson et al., 2015). With this perspective, examples of legitimate *scientific* culture would be an exhibited preference for canonical science-related science television programmes such as Horizon over 'popular science' television programmes such as Brainiac, or the ranking of fields of science by their supposed 'purity' (Pössel, 2013).

Bourdieu suggests the inverse ratio between popular taste and educational attainment explains why such cultural preferences were more prevalent in industrial and commercial employees in sometimes very senior positions compared with primary teachers who likely earned less but expressed greater preference for legitimate cultural goods and practices. This is perhaps the first clear indication of Bourdieu's argument regarding the arbitrary nature of culture, where he asserts that the education system is unequally responsible for the acquisition of cultural capital

and that there is a clear relationship between taste and education (Bourdieu, 2010). Disposition towards legitimate culture is taught, consciously or not, in the school system and by learning of the legitimate culture through scholastic practices (the choice of scientists taught about in the curriculum, for example) the student is taught to reject illegitimate culture as not having value in the academic market. In other words, what is taught in the science curriculum will be established as the only 'real' scientific knowledge worth knowing. Thus, it is to be expected that those with the highest educational levels, as we have seen belonging disproportionately to a dominant social class, will display tastes and preferences in science that are both legitimate and *legitimating* (Bourdieu, 2010).

Bourdieu & Passeron (1979) suggest that the 'right' dispositions and the parental transmission of a number of cultural capital-related factors – such as which courses to take and professions to pursue – results "in an unequal rate of scholastic achievement between the social classes" (p.13). This also translates to working-class students who have the prerequisite attainment for participation in certain post-compulsory courses (such as science A Levels) *to self-exclude*, because they lack the forms of cultural capital which recognise the current and future worth of the credentials associated with such courses (Adamuti Trache & Andres, 2008).

Bourdieu cautions against simply using the amount of time spent in education in order to reliably determine the volume of cultural capital an individual has. Instead he proposes measuring the amount of time devoted to its acquisition, as one has to consider the head start some children have before entering school and the 'handicap' other children have when their own form of cultural capital is not recognised by the school system. The further away it is from the scholastic market, the longer this takes to remedy (Bourdieu, 1986). Working-class children may have significant amounts of non-dominant forms of scientific knowledge, but formal science continues to privilege limited and specific forms of expert knowledge and will therefore *misrecognise* alternative forms as irrelevant or insufficient (*see* Chapter Two). The more distinct such alternative forms of cultural capital are from the science curriculum, the greater amount of time required for the students to become

realigned, an effort the school may not consider to be an appropriate use of their time.

Social inequalities in education become further entrenched because the education system supports the hereditary transmission of cultural capital through their legitimisation of that process (Bourdieu, 1986). Middle-class families with large amounts of cultural capital have greater prior knowledge of what capital has the greatest value for their child in the classroom, and the school then reproduces that capital by legitimising it and establishing an expectation that all students should work to internalise it. The school's systematic misrecognition of how their arbitrary (science) curriculum transforms social classifications into academic ones, and likewise of non-dominant science-related cultural capital and alternative scientific dispositions within the science classroom are forms of 'Pedagogic Action' (Bourdieu, 2000; James, 2015). Pedagogic action is where schools (institutionalised education) contribute towards the reproduction of social inequalities by actions which communicate to social actors 'the way things should be' or the *cultural arbitrary* (Bourdieu, 1990). Bourdieu stated that all pedagogic action was *symbolic violence* against the dominated/disadvantaged in that "it is the imposition of a cultural arbitrary by an arbitrary power" (Bourdieu & Passeron, 2000, p.5).

According to Bourdieu (1986), standard education is set at the minimum required for the labour least 'valorised' at any given moment. As not all social actors have the economic and cultural means to stay longer in education than the minimum required length, the cultural capital acquired in education is then unequally distributed, favouring those who stay in longer. As we have seen in Chapter Two, working-class students attending non-selective schools are significantly less likely to take Triple Science and significantly less likely to study science at A Level. Subsequently, it is middle-class students who disproportionately obtain and maintain dominant science-related cultural capital and eventually this misbalance is normalised. As Bourdieu stated, "ability or talent is itself the product of an investment of time and cultural capital" (Bourdieu, 1986, p.48). Middle-class students are then *expected* to be better at science, while working-class students internalise the idea that science is 'not for me' (L. Archer, Moote et al., 2016b) it has not been documented as

extensively, there is also evidence that Minority Ethnic families may also strategically draw on cultural, social and economic capital to facilitate their child's educational achievement and promote science persistence, *regardless* of social class, although this is seen less as a product of 'natural ability' but of hard work and diligence (L. Archer, Dawson et al., 2015; L. Archer, DeWitt et al., 2015).

Science Capital

The ASPIRES project has been key in promoting the inclusion of science-related resources as a form of cultural capital (L. Archer, 2013). Their conceptualisation of 'science capital' has been argued to act as a tool to understand the production of social advantage/disadvantage and for promoting social justice in science education (L. Archer, Dawson et al., 2015). *Science capital* is a composite measure of dominant forms of science-related cultural capital and social capital (*see below*) as well as scientific dispositions such as seeing utility in science qualifications and valuing science and scientists (L. Archer, Dawson et al., 2015; L. Archer, DeWitt & Willis, 2013). The project has used this measure as a survey tool to explain differential patterns in young people's science aspirations and science participation (L. Archer, Moote, et al., 2016a; DeWitt & Archer, 2015) and as a conceptual approach to teaching and learning which aims to value and build on students' existing forms of science-related capital (Godec et al., 2017).

Bourdieu claims that the education system is an integral institution in the reproduction of cultural capital, particularly with the embodied and institutionalised forms of cultural capital it generates. Further inequalities appear because economic and social rewards gained through educational qualifications can only go so far, and a certain amount of what Bourdieu calls *social capital* is required to secure these advantages (Bourdieu, 1986).

3.3.1.2. *Social capital*

Bourdieu states that *social capital* is the aggregate of actual and potential resources available in a social network or group. Membership of that group gives access to the privileges enjoyed by the wider network as a whole and has a multiplication effect on

the existing capital held by any one individual, the credit of which has symbolic value in other arenas. The amount of social capital possessed depends on the size of the network and the volume of other forms of capital both the social actor has, and the other network members have. It is Bourdieu's contention that the basis of any social group is the conservation and accumulation of capital (Bourdieu, 1986).

Like cultural and economic capital, social capital needs to be constantly invested in through strategies ultimately aimed at developing relationships that will be usable at some point. This carries with it increased practices of 'sociability' and investment of economic capital, which is only profitable if the individual carries competencies in being sociable and converting the capital to exchanges. The increased visibility through social activity and increased desirability of connection through an agent's large amounts of social (and cultural and economic) capital means their work of sociability has greater impact and reproduces their social capital. Through the social marketplace exchange process, for example trade or marriage, social capital is subsequently recognised by both parties and through this recognition the social network, or group, is reproduced. It also defines the limits of the group, what can and cannot be achieved. Those attempting entry into the group have to uphold the values of the group itself, and it is the responsibility of the members to 'vet' them, thus continuing the legitimate nature of the group (Bourdieu, 1986).

As stated by Bourdieu, profits are produced by the solidarity generated from association with membership of a group, and one cannot exist without the other. The more exclusively prestigious a group membership is, the greater the concentration of social capital. The members of these prestigious groups are then able to transmit their social capital to their children, and with this inherited social capital can transform any connecting relationships into lasting connections. This is a form of social reproduction (Bourdieu, 1986). Families as social groups can continue to control exchanges through institutions developed as part of their chosen lifestyle. For those with large amounts of economic and cultural capital, these will be 'legitimate' institutions in the form of prestigious places, occasions, and activities or 'practices'. While illegitimate institutions are excluded, the legitimate institutions bring together those with similar levels of capital who are eligible for group membership, thereby

sustaining the group's existence. Bourdieu uses the examples of accents and manners as indicators of membership to either a more or less prestigious group (Bourdieu, 1986).

The preservation of the social group is of the utmost importance, and as such some individuals, normally the most senior members, are assigned the responsibility of representing the interests of the group as a whole. These guardians have the ability to exert pressure on or against the group using the same power bestowed upon them by the group itself and can protect the integrity of the group by expelling any members who 'lapse'. Bourdieu critically observes that such mechanisms of delegation and representation also supply the possibility of the misuse of the capital accumulated (Bourdieu, 1986).

In a science context, having a member of the family working in a science-related job and/or with science qualifications means a child is far more likely to aspire to a science-related career (L. Archer, DeWitt et al., 2012b). According to the UPMAP survey, being encouraged to study maths or physics by a 'key adult' such as a teacher or family member was a significant predicator of a student's decision to study one of these subjects post-16 (Mujtaba & Reiss, 2013). Furthermore, talking to other people outside of school about science is considered to be one of the key components of dominant science-related cultural capital identified by the ASPIRES project (L. Archer, Dawson et al., 2015). If, as has already been suggested, there are far fewer numbers of White British working-class individuals taking formal science qualifications and therefore progressing to science professions, the numbers of White British working-class social groups able to receive the benefits from such an association will be limited. Those few White British working-class members who do hold dominant science-related cultural capital through qualifications and their work will be in the minority of their network, therefore science-related social capital will not be concentrated but diluted.

The hidden conversion of capital into future science success

We can understand in a more overt way how social inequalities are enacted through the possession of objectified cultural capital and the acquirement of embodied

capital, largely because of the influence of the bearer's levels of economic capital in obtaining either of those types of symbolic goods. Economic capital can be converted into dominant science-related cultural capital when it is spent on the purchasing of science resources as well as the enrichment activities mentioned above. After-school science clubs, visits to science museums and science sleepovers are all examples of premium activities that may exclude those without large amounts of disposable income to spend (L. Archer, Dawson et al., 2015). In the case of institutionalised cultural capital, affluent families can utilise their economic capital to send their children to selective or private schools more likely to offer desirable and high-status qualifications, such as Triple Science (*see* Chapter Two section 2.4).

The cyclical conversion of capital into its different forms can also be used to explain social differences in prior attainment, which, as has been outlined in Chapter Two, is one of the greatest predictors of progression to post-compulsory science. When students struggle with their work, affluent parents can convert economic capital into educational achievement by paying for tuition to ensure their child's success in maintaining the attainment required to obtain the desired qualification (L. Archer, Dawson et al., 2015). Even small differences in exam scores can equate to big differences in outcomes between individuals, as those either side of the cut-off point will have very different results. These small differences distinguish between those whose cultural capital is officially recognised and those whose is not. In the United Kingdom, students who fall short of the required B grade in science are largely not allowed by their school to progress to science A Levels – and subsequently study science at university (OPSN, 2015). Nevertheless, despite the subjective nature of both the cultural legitimisation of what is deemed to be good scientific knowledge for assessment sake, and the grade boundaries imposed at GCSE level, Bourdieu would argue that institutional recognition appears to offer an apparently objective comparison between qualification holders (Bourdieu, 1986).

Bourdieu posits that the rarer a cultural object is, the greater value it has. The comparison between qualification holders and between the values of the cultural object enables agents to establish a 'conversion rate' between the amounts of economic capital invested in the acquirement of cultural capital. For qualification

holders (and their families) it is then expected that the academic qualifications will be exchanged on the labour market for salaried positions, thereby reversing the conversion that had already taken place (Bourdieu, 1986) (*see also* sub-section 3.5.1). The special status of science means science qualifications are likely to be seen by middle-class parents as a good investment when strategically applying inherited cultural capital on the 'scholastic market' (Adamuti Trache & Andres, 2008; Bourdieu & Passeron, 1979). University-educated parents are argued to be more likely to perceive institutionalised capital e.g. examinations, qualifications, etc. related to science as leading to high-status careers in science or engineering, the development of an exclusive set of skills or simply facilitating the transition to post-compulsory education. Furthermore, access to, and the acquisition of, exclusive institutionalised capital determines social status and enables entry to privileged social classes (Claussen & Osborne, 2012). Thus, access to Triple Science, a route and qualification which arguably holds greater cultural capital than Double Science (*see* Chapter Two section 2.4), enables entry to the privileged middle-classes.

As alluded to already, some goods and services cannot be obtained through economic means alone and so the employment of other forms of capital is required. Bourdieu contrasts what he terms the 'cynical' immediacy of economic exchanges with the ambiguity and long-term investment of social capital. He states that unless the social relationship is a long-standing and well-maintained one, a social agent's social capital may have to mature long before being enacted (Bourdieu, 1986). He goes on to argue that cultural and social capital is essentially derived from economic capital that has been transformed or converted. As we have already seen, however, they can only be effective in their own particular form of capital if the fact that they are sourced from economic capital is disguised (Bourdieu, 1986). A parent may use economic capital to send their child to a private school with notable links to professional networks through their alumni – including in scientific professions and especially the high-status medical sector. This initial investment gives added value to their child's attendance at such a school and students feel more confident they can use their connections to attain the job they desire (Green et al., 2015).

Cultural capital can be traced back to economic capital because one needs the latter to undertake practices that develop cultural capital. Furthermore, the greater the amount of economic capital one has, the greater the amount of free time available to devote to the acquisition of cultural capital. This is particularly the case if the social agent is able to purchase the time of others to undertake their labour for them. Thus, Bourdieu concludes that the convertibility of the different forms of capital functions as the foundations of the strategies employed in ensuring the reproduction of capital. These strategies are predicated on the work required in the conversion and the risk of loss based on the social power relations involved (Bourdieu, 1986).

It would be tempting to surmise that the relationships between forms of capital are messy and there are therefore largely indistinguishable from one another. Bourdieu, however, does offer some help on their differentiation. He states that they can be told apart based on how easily they are transmitted, and this can be measured by both the amount of profit or loss involved in the transmission and how easily the transmission can be concealed (Bourdieu, 1986). The transmission of *cultural* capital is more easily concealed and therefore it can more easily be lost. In its institutionalised form (educational qualifications) it cannot be transferred, nor can it be negotiated. The more the official transmission of capital is limited, for example through inheritance laws, the more subjects revert to the less conspicuous practices of transmitting cultural capital as a means of reproducing the social structure.

Parents with large amounts of cultural capital are likely more aware of the value of science-related forms of capital and their potential for conversion back into economic capital. While they cannot transfer any science qualifications they themselves hold to their children, they can labour to convey to them as much of their dominant science-related cultural capital as possible, supplemented by the activities and practices mentioned before to account for any capital lost in transmission. These continued exercises eventually instil a disposition towards science, forming part of what Bourdieu calls 'habitus'.

3.3.2. Habitus

The notion of *habitus* is perhaps the most complex of Bourdieu's 'conceptual trinity'. It is not a new idea, existing long before Bourdieu resurfaced the term, and has connections with the classical concept of 'habit'. For Aristotle, a 'habit' is developed from the practice of similar acts and inclination to similar acts. The main difference between the two concepts of habits and habitus being that one can acquire habits, but it is the internalisation of those habits through socialisation that renders them innate and therefore 'habitus' (Nash, 1999).

As we have already seen, there is a strong relationship between capital and habitus, whereby forms of capital can become embodied and therefore part of one's habitus. With habitus, Bourdieu was attempting to bridge the external objective of society and the internal subjective of the agent (Reay, 2004). He notoriously disliked definitions, but he did offer the following to explain this rather abstract idea:

> The habitus, as the word implies, is that which one has acquired, but which has become durably incorporated in the body in the form of permanent dispositions... Moreover, by habitus the Scholastics also meant something like a property, a capital. And, indeed, the habitus is a capital, but one which, because it is embodied, appears innate.

> (Bourdieu, 1993 p. 86)

Bourdieu elsewhere explains habitus as the result of internalisation of structures through socialisation (Bourdieu, 1998). This process of internalisation affects one's dispositions and therefore behaviour and thinking and can continue to affect the agent long after the conditions (field) initiating it have ceased to exist. The same habitus then activates different practices depending on the field it is operating in at the time (Reay, 2004). As a result, habitus leads the agent to reproduce the social conditions or structures that constructed her/him. The habitus constrains the agent to operate their agency within the limitations imposed upon them by the field, meaning they can tend to be predisposed towards certain practices. Such a notion left Bourdieu open to accusations of determinism, to which he argued that habitus is not an exact art and should be associated with vagueness (Bourdieu, 1990).

To further explore this idea of the reactive habitus, one can view habitus as a product of an agent's individual history - including both their family history and their own personal experiences:

> Habitus… is the product of all biographical experience (so that, just as no two individual histories are identical, so no two individual *habitus* are identical, although there are classes of experiences and therefore classes of *habitus* – the *habitus* of classes).

(Bourdieu, 1993 p. 46)

Habitus is structured rather than random and constrains rather than determines thought and action (Reay, 2004). Habitus gives a sense of one's place and the place of others and is reflective of both individual and collective practices. Reay explains that habitus is individual but as a structure can also be shared within social groups. As a consequence, agents may sometimes exclude themselves from experiences not common to their sociocultural group (Reay, 2004). As has been argued earlier in this chapter, through their relative lack of social contacts in science professions and poor participation rates post-16, White British working-class students may as a result perceive science to be an alien practice more suited to others. The *class* of White British working-class habitus may well dismiss science as 'out of reach'. This makes the WBWC student who does aspire to continue in science all the more exceptional, but who may have to do additional work to overcome the poor expectations held by peers, parents and teachers, through the development of an individual habitus which sets them apart from many of their WBWC peers.

The notion of *institutional habitus* can help us to understand why some schools offer different curriculum and qualification options. Institutional habitus has been conceived as related to the educational status of institutions – the more prestigious a school, the more prescriptive they are about having the 'right kinds' of traditional subjects, knowing that these are the ones which will be expected at traditional universities; Triple Science has been described as an example of the 'right kind' of qualification (Reay, David, et al., 2001). Institutional habitus, either that of the wider school or of the science classroom can also be said to mediate the habitus of WBWC

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students (Ingram, 2009). For example, the streaming practice of GCSE science into Double or Triple Science pathways, and the elite connotations associated with the latter, can construct a habitus which either includes or excludes students from science (Zevenbergen, 2005). The greater likelihood of WBWC students being placed or channelled in Double Science increases the chances that they will develop a habitus which, for them, constrains the possibility of success in science.

Bourdieu talks somewhat about science in relation to habitus. In his 1975 article *The Specificity of the Scientific Field and The Social Conditions of the Progress of Reason,* Bourdieu discusses the nature of *scientific* habitus as the internalisation of the 'scientific method' manifested as scientific disposition. He explains that scientific habitus generates certain systems of 'perception and action', guiding the choice of objects or equipment to use, how to approach problems and how to evaluate solutions (Bourdieu, 1975). This can also be equated to the dispositions recognised within canonical science as discussed in Chapter Two.

The role the habitus plays in reproducing social inequalities is by corroborating with institutions who continue to produce and reproduce scientific goods in a particular manner by only training 'legitimate' recipients of science education in the manner of the *scientific habitus*. In other words, schools, universities and places of work such as laboratories collude in protecting their shared interests by only recognising and advancing students who have developed a legitimated scientific habitus.

Bourdieu had two models of class reproduction through habitus, one where there are multiple habitus in a class and the other where the habitus is shared wholly by a class. Nash argues that the first one is most useful to ethnographic researchers while the second is preferred as a 'pseudo-statistical' model. According to Nash, Bourdieu did not invent the latter model of habitus but nevertheless seemed to adopt it. Nash criticises this latter model as an ill-conceived argument of determinism and of group access rather than individual access – giving no explanations as to why the trajectories of those within a class can vary (Nash, 1999). Because of these concerns one should be aware of these two different models and be mindful of which one is being used in social science research. This thesis uses the model recognising multiple

habitus in a class, and in particular habitus that can be defined by and attached to a local context. The participants, while all considered to be White British working-class, are located in very different areas – ranging from the urban to the coastal to the countryside. Their habitus will be influenced by an internalisation of their gender, ethnicity, social class, and local environment and therefore their location and surroundings will need to be considered as part of the substance of the habitus. Bourdieu conceptualised the varying contexts in which a social agent's habitus operates as the *field*.

3.3.3. Field

According to Warde (2004), the concept of 'field' was one that took the place of an established theoretical idea which Bourdieu had developed extensively in the earlier part of his career, that of 'practice'. They are both concepts, Warde argues, which are promising candidates for use in analysing the 'meso-level' aspects of structural and institutional change (Warde, 2004). There are various possibilities suggested for Bourdieu's abandonment of practice in favour of field; mostly related to its perceived lack of usefulness in empirical analysis and the recognition of its most valuable traits being present in both field and habitus. Whatever the reason, it is clear by the demise of the term practice and the rising prevalence of field theory in Bourdieu's later work that he considered field to be a more substantial and self-sufficient construct.

In his article *The Social Space and the Genesis of Groups*, Bourdieu conceived sociology as a form of social topography. According to Bourdieu, the social world exists in multi-dimensional space and cannot be defined simply by the restrictive principles of economy and economic production (Bourdieu, 1985b). Rather, social space or 'fields' are determined by sets of distributional and differentiation principles made of properties relevant to that particular social space. These properties are a 'field of forces' or 'objective power relations' that are active on all inhabitants or 'members' of that social field (Bourdieu, 1985b).

Bourdieu believed that membership to a social field is accompanied by varying amounts of information or 'capital' pertinent to the field's principles and that the field's structure is based on the (unequal) distribution of said capital amongst the

social actors who are its members (Bourdieu, 1975; 1983; 1986). Members are positioned within the social field based on their volume of capital and the composition of their capital; members, or as Bourdieu also calls them 'agents', and collectives of agents are then defined by their relative positions within social space (Bourdieu, 1985b). These positions impose themselves on agents and institutions (Bourdieu, 1996). The existence of a field is therefore fundamentally dependent on the actuality of social agents and objective institutions (Naidoo, 2004).

The metaphysical nature of fields, intrinsically reliant on its components of agents and institutions, means that social fields are not necessarily distinct, clear-cut entities but instead are dynamic and ever-changing (Bourdieu, 1993; M. Grenfell & James, 2004). Bourdieu explains that it would be unhelpful for the social scientist to draw an arbitrary line to divide the agents within in the interests of forming a field's boundary, but instead should conceive the boundary as a 'state of struggles', where those agents with the most dominant capital protect the field's frontier (Bourdieu, 1983). Such struggles take place within social fields either to conserve or transform the forces inherent within (Bourdieu, 1983).

In his writing on the scientific field, Bourdieu claims that the struggle in the field is for a stake in 'scientific authority' and the forms of capital associated with it – in this instance cultural capital in the form of technical competence or 'scientific expertise' and social capital in the form of recognition and legitimisation of one's dominant position in the field (Bourdieu, 1975). The struggle in the field of science education is somewhat different, as it is argued secondary school science does not reflect the nature of scientific research, being far more focused on conceptual content than scientific method or 'how science works' (McGregor & Kearton, 2010; Millar, 2012; Sinatra et al., 2014). Instead it is the struggle to attain a prominent position within a field that, due to its prestigious nature invokes competition. Middle-class students with greater amounts of dominant science-related cultural capital will fare better in the field because the recognition of their capital from the school consolidates their position and their habitus dictates an expectation of belonging. They will fight, through deploying their science-related capital in all its forms, to ascend to the most privileged positions: the top set of science, a place on the Triple Science award, etc.

Any White British working-class students attempting to engage in the struggle will therefore suffer a considerable disadvantage, subsequently paring their aspirations to less prestigious science-related qualifications and professions where they may have more success.

Much like their fluctuating boundaries, the locations of fields themselves are also dynamic. Social fields assemble together, their relative autonomy depending on the fields in question, the period in time and from one national tradition to another. Bourdieu reinforces his argument that the field and its elements are interdependent with the assertion that a field's power relations depend on the autonomy of the particular field; on how successful the field is at imposing structures and guidelines on the producers within it (Bourdieu, 1993; Naidoo, 2004). Scientific research is, as Max Weber puts it, "the affair of an intellectual aristocracy" (Weber, 1946, p.134). As such, the imperative to protect its borders will be all the more ferocious and those within the field will be kept in line. As Bourdieu notes, scientific authority is a particular kind of social capital that only has value in the scientific field itself and due to its nature, this is the only space where it can be legitimated. Indeed, the recognition process is all the more robust as the agent seeks validation from their competitors as the only consumers within the field. The more autonomous a field is, the more reliant the agent is on the competitors in legitimising this social capital (Bourdieu, 1975).

The lack of use for dominant science-related cultural capital outside of the scientific field contrasts somewhat with other forms of cultural capital. Bourdieu states that cultural capital is only active, both symbolically and materially, when it is being used strategically in the field of cultural reproduction. He argues that the amount of the agent's profits in the field of cultural reproduction will be proportionate to their mastery of objectified capital and the extent of their embodied capital (Bourdieu, 1986). This is significant because capital constitutes power over the field in any one particular moment; fields are the context of scarce resources and agents with the most capital can compete more effectively for remaining capital and therefore reproduce the capital by determining the rules of the market/functioning of the field (Bourdieu, 1985b; 1986; Crozier et al., 2008). Capital is both product and process

within a social field (M. Grenfell & James, 2004). White British working-class individuals, significantly under-represented in the field of science education, largely have the least amount of dominant science-related capital. They do not have the means to engage in cultural reproduction in other fields – the field of science policy, for example, will be dominated by the privileged middle-classes who use their prevailing influence to direct matters to their liking.

The interplay between *habitus* and *field* is what Bourdieu calls a 'feel for the game'. This familiarity is based on a member's experience of the game/field and of the objective structures within the field that make it up. Agents in dominant positions are native members of the field, with an understanding of the history of the field and are thus able to instinctively anticipate the future in such a way that everything that takes place in the field seems reasonable and logical (Bourdieu, 1996; Bourdieu & Wacquant, 1992). Bourdieu argues that the habitus makes meaning of the field while also being shaped and conditioned by it (Bourdieu, 1986). Middle-class families with large amounts of cultural capital have greater awareness of school mechanisms and can navigate them more successfully. The 'concerted cultivation' discussed previously is an example of the "seamless transmission of cultural capital and familial habitus to enable the operationalisation of the rules of the game" (Crozier, Reay et al., 2011 p. 200). Elsewhere, Bourdieu describes the encounter between a habitus and the social world which produced it as "like a 'fish in water': it does not feel the weight of the water and it takes the world about itself for granted" (Bourdieu & Wacquant, 1992, p.127). Being 'a fish in water' in formal science education has often been expressed as being 'at home' in science or seeing science as something 'for me'.

Bourdieu saw the field as the 'locus of struggles'; it is in constant tension between agents and groups of agents struggling to position themselves at the best location, with the best view and the best prospects (Bourdieu, 1975). Such struggles are prevalent in the field of class relations which Bourdieu says has no impartial judge of legitimating forces and the agents that are successful in their claims to legitimacy are those who belong to the strongest groups which share their interests. There is no benign force able to regulate the inequalities of the science field, and therefore it should come as no surprise that the conditions developed by the middle classes with

their particular form of legitimised science-related cultural capital in mind continue to favour the same types of people and exclude those who do not fit. Such is the arbitrary nature of the field (Bourdieu, 1975).

In a similar vein to Zevenbergen's (2005) Bourdieusian analysis of mathematics education, it is arguable that structuring practices of science education field, such as ideological positions on hierarchies of knowledge and differentiated aims of science curriculum (i.e. science for all vs. science for future scientists) provide a context where ability-setting and multiple science pathways are seen as acceptable or desirable. Furthermore, setting, assessment, subject choices and examinations have been used as selecting and sorting practices within schools for some time, positioning agents (students) in a social hierarchy differentiated by the agent's cultural capital (P. Thomson, 2005). Indeed, Triple Science and restricted access to science A Levels based on prior attainment could be argued to be examples of middle-class policing of class/field boundaries in science education, resulting in segregation along class and ethnic lines (Reay, 1998).

3.4. Limitations of Bourdieu's work

Bourdieu's theories have had a profound influence on how we conceive social inequalities, with his concepts used as tools to expose the mechanisms used within education, and as in the case of this thesis, science education, which contribute towards students from certain backgrounds being under-represented in post-compulsory science fields. However, despite his popularity in educational research, and increasingly in science participation research, a number of limitations have arisen which should be considered when using his ideas.

As referred to earlier, one of the most common criticisms of Bourdieu's work is that the concept of habitus is deterministic (Nash, 1990; Reay, 2004). In his defence, his advocates point to habitus as a dynamic 'matrix of action' (Lizardo, 2004), which does indeed reflect one's social background but is also permeable in response to highly individual biographical experiences (Reay, 2004). Bourdieu himself states that the theory of habitus is not deterministic, but one's habitus does "help to determine what transforms it" (Bourdieu, 2000, p.149). This in turn has been critiqued for failing

to consider the role of agency or reflexive action, in particular with regard to structural change from *inside* social systems, to which they suggest supplementing Bourdieu's ideas with those of other theorists such as Sen's *capability approach* or the critical realist tenet of *emergence* (Abel & Frohlich, 2012; Decoteau, 2015; Gokpinar & Reiss, 2016). While it is not the intention of these criticisms to dismiss Bourdieu's ideas entirely, they do highlight the somewhat pessimistic outlook his theories present, particularly with regard to making changes within science.

Bourdieu has also been criticised for inadequately conceptualising economic capital while still extrapolating it to his other – more extensively developed – forms of capital (Fine, 2002). As Skeggs (2004b) notes, "practice never ceases to conform to economic calculation" (p.85). Indeed, the 'exchange relations' lens of Bourdieu's theory runs the danger of only presenting the 'concerted cultivation' practices of middle-class parents as either a form of market processes or as a form of class oppression. The rather cynical perspective that parental support is limited to the investment of exchangeable resources or the protection of class boundaries obscures the fact that, regardless of social background, most parents do usually want the best for their children – although, as Crozier, Reay et al. (2011) point out, what that means to parents may vary. This standpoint also treats the middle classes as a homogenous group, instead of recognising that some may choose not to activate their social and cultural capital or may not have the required skills to do so (Lareau & McNamara Horvat, 1999).

Bourdieu's cultural approach to social reproduction brings with it further concerns. Despite his exploration of the arbitrary nature of culture, Bourdieu (and his collaborators) have been noted to frequently use the term 'cultural capital' interchangeably with 'legitimate culture' (Prieur & Savage, 2011). This is problematic when it fails to recognise the value present in non-classical, 'elite' cultural forms and instead equates legitimacy with the tastes of the dominant classes (Warde & Gayo-Cal, 2009). Science participation researchers have attempted to address the deficit associations this attaches to the culture of marginalised communities by using a theoretical framework – Funds of Knowledge – which designs classroom activities derived from science-related forms of knowledge found *within* the marginalised

communities themselves (Basu & Calabrese Barton, 2007). However, such 'cultural difference' style approaches have been criticised for implying different solutions for different cultural groups (which is difficult to apply in a multicultural school environment) and for failing to allow for the possibility that science itself may need to be transformed (Carlone & Johnson, 2012).

Bourdieu intended for his ideas to be considered as 'open concepts' rather than fixed and rigidly defined, which he explained was an inappropriate way of trying to understand a reality which is "imprecise, fuzzy (and) woolly" (Bourdieu & Wacquant, 1992, p.23). However, while a number of scholars have taken up Bourdieu's invitation to develop his theories to help explain their empirical work (Nash, 2010; Reay, 2000), others have observed that the practice of converting his ideas into variables has resulted in 'disappointing' empirical research which has often "decontextualised key concepts from the broader theoretical mission" (Lareau & McNamara Horvat, 1999, p.38). Lareau and McNamara Horvat also note that the richness of Bourdieu's overall theoretical framework has come at the expense of specificity over issues such as the different ways institutional agents legitimate or reject attempts by individuals to leverage their resources, or instances of reproduction and exclusion (Lareau & McNamara Horvat, 1999). Naidoo (2004) similarly mentions Bourdieu's tendency to provide the first and final steps of how dominant social hierarchies are reproduced, but not the steps in-between. She suggests that while Bourdieu's theories and concepts can be difficult to use from a methodological perspective, nevertheless they remain valuable as analytical 'thinking' tools.

The parts of the chapter preceding this section have gone into great detail to explore the insights Bourdieu's theories bring to understanding the role of social class in inequalities within science participation. However, his consideration of other sociocultural factors has been considered by many to fall short. Bourdieu has been observed as tending to focus on social class with a presumption of Whiteness (L. Archer & Francis, 2006). His lack of consideration of ethnicity means Bourdieu's ideas are limited in explaining, for example, how certain Minority Ethnic students, such as from South Asian backgrounds, facilitate success in science, regardless of social class. His treatment of gender has been equally charged as "less than vigorous", for

example his essentialist presentation of gendered dispositions (McCall, 1992, p.839). While some science participation scholars have responded by considering gendered dispositions as another form of capital (Adamuti Trache & Andres, 2008), others using Bourdieu have additionally turned to feminist theorists in order to explore the role of gendered identities in perpetuating the under-representation of women in science fields (L. Archer, Moote et al., 2016a).

3.5. Beyond Bourdieu

A number of scholars have extended and developed Bourdieu's ideas to address some of the limitations discussed above. Their approaches have allowed research on educational participation to, amongst other things, deal more appropriately with the complexities arising from the interaction of social class with gender, ethnicity and other sociocultural factors; to observe with greater specificity the part institutions play in recognising the resources of certain students and not of others; and to appreciate that cultural resources can have a different kind of value to different groups, which in itself can be a source of social inequalities. These ideas are discussed further in this section, once again with their implications for science participation.

3.5.1. Use and Exchange-Value

Use-value and *exchange-value* are Marxist ideas which distinguish between the value attributed to an object because of its material utility (limited to its physical properties) and the relational value an object has i.e. "the proportion in which values in use of one sort are exchanged for those of another sort" (Marx, 1867 p. 27). For Bourdieu, the commodification of culture in late-capitalist society meant the use-value of symbolic goods has been gradually colonised by their exchange-value in the economic market (Susen, 2011). Nonetheless, Bourdieu's theorisation of classed differentiation in the exchange-value of cultural goods was limited, as indicated by the previous section.

Beverley Skeggs' work has been extremely influential in exploring how systems of exchange add value to certain characteristics such as social class, race and gender (Skeggs, 2004a). Drawing on imperialist metaphors, Skeggs distinguishes between the European colonialist who only sees the value of objects through exchange, while

the 'primitive' imbues their objects with personal history and memories (Skeggs, 2004a; b). Skeggs' framework thus keeps exchange-value and use-value separate, arguing that an asset can have use-value to a person (the primitive), but it can be exchanged by force with a more powerful social agent (the colonist) with greater power, rendering the exchange unequal (Skeggs, 2004a). In contemporary society, the hypercommodification and industrialisation of culture means it has become a site central to the exchange of values (Reay, Hollingworth et al., 2007; Skeggs, 2005b).

Skeggs theorises that Bourdieu's notion of habitus and the strategic accumulation of cultural capital positions culture "as an exchangeable-value in which some activities, practice and dispositions can enhance the overall value of personhood" (Skeggs, 2004b, p.74). Thus, the parent educating the middle-class child in scientific culture e.g. taking them to science museums, science festivals, watching Christmas Lectures at the Royal Institution, etc. is doing so because it is assumed to be 'morally good' for the child, but also because of the activities' future potential exchange-value converted into 'employability' in the labour market and/or 'being cultured/educated' in social networking (Skeggs, 2004b). The 'natural' association between exchange-value and morality means that working-class families who don't pursue such (middle-class) types of cultural activities are positioned as immoral; pathologised as failures - in choice, in culture and in enterprise (Skeggs, 2004b). Meanwhile, science-related activities or knowledge which have use-value i.e. based on personal experience and held within the wider community – such as that within the Funds of Knowledge framework (*see above*) – are not recognised as having value outside the circumstances within which they are enacted or produced. These resources have the potential to have exchange-value, but the working classes do not tend to have the dispositions (or knowledge of 'the rules of the game') to actualise them, being unaware of the current 'exchange-rate' (Rios-Aguilar et al., 2011).

The notion of exchange-value can be used to understand the difference in values of institutionalised science-related cultural capital, as touched upon in sub-section 3.3.1. As indicated there, the relative scarcity of graduates with science qualifications means, as a cultural object, such qualifications hold greater exchange-value in the labour market than qualifications from, for example, the arts and humanities

disciplines. This can also be applied to qualifications within science itself to analyse the difference in status with, for example, Double Science vs. Triple Science. I have already discussed in Chapter Two how the Double Science GCSE award is (officially) considered to be adequate preparation for ongoing science participation. As a form of scientific training, its use-value (should be) sufficient enough for students to progress to science A Levels, although this brings with it practical difficulties for the teacher faced with a mixed class of Double and Triple Science awards who have significantly different levels of subject knowledge/dominant science-related cultural capital (Millar, 2011). Nevertheless, it is the rarer, harder-to-access Triple Science which holds the greater exchange-value for successful transition into science A Levels and onward to higher education.

One can also extend the argument to academic science A Levels and vocational or applied science courses – regardless of use-value, it is the academic courses which hold the greatest exchange-value for students wishing to continue science along the traditional 'pipeline'. Indeed, as noted elsewhere, the tendency within school-based (usually academic) science courses to prioritise abstract ideas over practical application, as well as teaching and assessment practices which focus on obtaining optimum exam results rather than depth of learning, represent arbitrary forms of exchange-value (Black & Hernandez-Martinez, 2016). Meanwhile, the use-value of science in most school science courses is marginalised, despite its potential to engage students with science within the classroom and for providing future scientists with the requisite skills to function in a scientific workplace.

The science classroom becomes a site for the unequal exchange of goods when the middle-class parent undertakes numerous strategies to obtain science-related cultural capital with the greatest exchange-value. While the force used is not in the physical manner as the colonists described by Skeggs, middle-class parents have been found to aggressively pursue educational resources for their children, even at the expense of disadvantaged children (Crozier, 1999; Francis & Hutchings, 2013; Montacute & Cullinane, 2018; Reay, 2005; Useem, 1992). While teachers can find such parental involvement frustrating, they simultaneously frame the lack of such engagement on the part of working-class parents as due to lack of interest (Reay,

2008). Indeed, within wider educational and policy discourses, the competitive and 'pushy' (colonial) tactics of the middle classes are valorised and the working classes are expected to emulate them in order to be seen as 'good parents' (Gewirtz, 2001). In other words, the unequal exchange of (high-value) science-related cultural capital undertaken by middle-class parents is constructed as virtuous, while the morality of working-class parents is, again, placed in doubt.

To expand further, Skeggs argues that it is the *relationships* involved in exchange which hold importance, rather than the objects themselves. Thus, some social agents can use class, ethnicity and gender as a cultural resource while others are simply 'fixed' by these values, rendering them non-transferable – for example, the cultural resources held by White working-class women have restricted exchange-value as they are not perceived as legitimate or authentic by those implicit in the dominant systems of exchange (Skeggs, 2004a). Conversely, White middle-class males, frequently presented as the prototypical, idealised scientist (*see* Chapter Two sub-section 2.5.2), can leverage these characteristics for recognition within the science field and for privileged access to science-related cultural capital with the highest exchange rate. So, the White middle-class male converts his cultural resources – his gender, social class, ethnicity as well as forms of cultural capital such as that derived from attendance of science museums, etc., with other forms of economic capital and social capital (*see* sub-section 3.3.1) – into high-status school science qualifications, which in turn are converted to high-status university degrees and then employment in high-status STEM sectors. These conversions are numerous, ongoing and invisible, and a form of symbolic violence which reproduces unequal participation in science.

3.5.2. Intersectional research

Of course, Bourdieu is not alone in his less than satisfactory treatment of race and gender, and even when science participation research does take them into account as factors, they are often handled separately from one another. While feminist scholars laid down the challenge to recognise the male biases in the production of scientific knowledge, their rallying-cry has been criticised as being limited by its reflection of a Eurocentrist, middle-class female perspective (Collins, 1999; Ferree et

al., 1999; Mendick, Berge et al., 2017a). An *intersectional* approach was advocated, where diversity analyses view how "the intersecting hierarchies of gender, race, economic class, sexuality and ethnicity… operate within scientific discourse and practice" (Collins, 1999, p.263). Framed as a 'matrix of domination', intersectionality has been suggested to reveal how multiple forms of oppression interact to reproduce inequalities in science (Collins, 1991; 1998; 1999).

Emerging from the Black Feminist movement, intersectionality complicates our understanding of identity categories such as race, gender and class; in other words, rendering *Whiteness* visible as a racialised identity, rather than the universal (Meer & Nayak, 2015). Thus, intersectionality allows us to see the similarities *and* differences in the nature of oppression facing, for example, White working-class women and Black working-class women. While Black working-class women face additional inequalities because of their race, this has also been a stimulus for the ongoing development of a 'culture of resistance' shared amongst Black women; there is a history of a Black female intellectual 'elite' shaping, and being shaped by, the wider Black female community, whereas White working-class women have a less conspicuous place in resistance struggles (Collins, 1991). Studies have shown White working-class women tend to have a more complex relationship with feminism and have been found to diminish the extent of their cultural capital in relation to men, while Black working-class women often celebrate and distinguish their feminised cultural capital (Luttrell, 1989; Skeggs, 1997). There is evidence, also, of White working-class females particularly dis-identifying or reporting a tension with their social class positioning within 'elite' institutions such as universities (Barker, 1996; Reay, Davies et al., 2001).

An intersectional approach, therefore, brings nuance to our understanding of the ways different groups can be marginalised within social spaces defined by dominant modes of thinking and practice. In the case of science, intersectionality adds complexity to diversity discourses by, for example, highlighting the role of ethnicity and social class in marginalising males from Minority Ethnic and/or working-class backgrounds (*see* Chapter Two, sub-section 2.5.3), or by revealing Black working-class girls to be amongst the most disadvantaged in the field of science due to being

subject to multiple forms of inequalities (L. Archer, 2013; L. Archer, DeWitt et al., 2015). Within this thesis, an intersectional lens has allowed me to explore how class and race interact to oppress WBWC ways of being within the field of science, but also the additional role of gender in that oppression. I consider this complexity to be a vital part of improving our understanding of the mechanisms underlying WBWC under-representation in science.

3.6. Summary

This chapter has introduced the theoretical resources I have drawn upon in this study exploring the under-representation of White British working-class youth in post-compulsory science courses. It began with a brief discussion of 'social class' as a theoretical and empirical notion, followed by the conceptualisation of class used within this thesis. This was followed by an in-depth analysis of Bourdieu's social reproduction theory, drawing on his original ideas of capital, habitus and field, and a discussion of how they have been used within science and wider educational participation research. His theories have offered a range of conceptual tools with which I have conducted my analysis, including but not limited to: parental transmission and investment of dominant science-related cultural capital; the field of science education and how some members are able to position themselves more advantageously than others; the idea of a 'scientific habitus' and what that should – or might – look like.

Following this I examined some of the limitations of Bourdieu's work, including his narrow consideration of ethnicity and gender and the lack of worth he seems to attribute to non-dominant forms of cultural resources. I then outlined how Skeggs' conceptualisation of 'use-value' and 'exchange-value' can be used to analyse how different forms of science-related cultural resources are recognised and subsequently leveraged, or not, within the field of science education. Finally, in this chapter I examined the importance of intersectional approaches to research in exposing the interplay of social class, ethnicity and gender in the reproduction of inequalities in science participation. The next chapter will present the methodology with which I undertook my study.

4. Methodology

4.1. Introduction and research questions

The first chapters of this thesis have established the context in which the research reported here took place. Chapter One set out the rationale for investigating White British working-class (WBWC) science participation, Chapter Two outlined what sociocultural factors have been found to be associated with participation in science, and what is known about WBWC participation in education more generally, while Chapter Three discussed the theoretical grounding of the research, examining how Bourdieusian theory augmented with intersectional perspectives could be used as a lens to explore why WBWC students are under-represented in post-compulsory science fields. Three research questions emerged which this thesis aims to address:

1. What is the nature of WBWC youth engagement in out-of-school science, and how does it change over time?
2. What, if any, is the relationship between out-of-school science engagement and WBWC students' participation in science A Levels?
3. What are the possible mechanisms influencing WBWC students' choice between Double Science or Triple Science pathways, and what ways may this choice affect their ongoing science participation?

This chapter provides an account of the methodological strategy used to answer the research questions posed above. By rendering transparent the decisions and processes undertaken throughout the course of the research, the chapter aims to substantiate the validity of the findings reported in subsequent chapters. It begins with a discussion of the philosophical considerations which informed the research, including how they fit with the use of Bourdieusian theory; this is followed by an outline of the research design, including a description of the data collection methods and the participants, and an overview of the analytical processes including how these were guided by the research paradigm. Discussions of strengths and limitations will occur throughout to underline the implications of the methodological approaches taken by myself and by the ASPIRES projects within which this study is situated.

4.2. Philosophical assumptions of the research – ontological, epistemological and axiological

Within the field of social science, it is generally considered good practice that any critical examination and articulation of methodology must include a discussion of the ontological, epistemological and axiological positions of the research (Bourdieu & Wacquant, 1992; Dillon & Wals, 2006). Ontology is concerned with the nature of reality, while epistemology is the study and theory of knowledge and axiology is a branch of philosophy dealing with ethics, aesthetics and religion (Dillon & Wals, 2006; Lincoln et al., 2011; Morgan, 2011). It is believed that making the philosophical grounding of research explicit renders transparent the researcher's own perspective and allows for a discussion of the subsequent implications for the methodology and methods used (Hart, 2000). This section is a discussion of my (as author of this thesis and architect of the research reported within it) worldview, and how this helped to identify the most appropriate methodology to capture the 'reality' of the human experience under scrutiny (Mertens, 2007), including how this fits with the Bourdieusian theory I used in my analysis.

The research depicted in this thesis is concerned with exploring the under-representation of WBWC students in formal science education fields. As mentioned previously, there is a dearth of literature in this area, thus the research draws on research in informal and formal science education, equity issues in science and WBWC students' engagement in education more widely. The previous chapter outlined how the theories of Bourdieu and other intersectional research can be used to explore the role of social reproduction in the issue at hand. Thus, social justice underpins both the context of this research, in the marginalisation of WBWC in science and the lack of research exploring this phenomenon, and the spirit in which it was undertaken. Social justice and equity have informed both the axiological and the epistemological perspectives in this research. This section outlines these discussions, including the ontological position within which these perspectives are situated.

4.2.1. Identifying a suitable research paradigm

In taking an ontological position, a social science researcher is making claims about what kinds of social objects do or can exist, the conditions of their existence and the relationship between the two (Blaikie, 2007). A researcher's epistemological position makes clear how they believe knowledge is made, including beliefs about its distinguishing characteristics (Dillon & Wals, 2006; Morgan, 2011; Schmidt, 2001). Meanwhile, their axiological position is a researcher's values and ethical considerations (Creswell, 2003; Dillon & Wals, 2006; Mertens, 2007). This sub-section briefly discusses the two most common research paradigms within the field of social science and why both were dismissed as inappropriate for the research reported in this thesis.

In the philosophy and methodology of social science, two antithetical positions have historically dominated the field – *positivism* and *interpretivism* (Mingers, 2014; Sayer, 2000). Briefly, the positivist ontology is *realist*, asserting that an independent world exists (and the positivist belief that it is deterministic), and claiming that epistemologically, this external reality can be known objectively; thus, the laws of the universe can be discovered and known (Morçöl, 2001). Interpretivism, meanwhile, holds a *relativist* ontological position, claiming that there is no true independent reality, merely our perceptions of it, and adopts a *constructivist* epistemology, claiming all knowledge is subjective; thus, instead of hoping to find explanation it is concerned with the interpretation of meaning (M. Archer et al., 2016; Denzin & Lincoln, 2017; Potvin et al., 2010; Sayer, 2000).

Both paradigms have been subject to intense scrutiny, with interpretivism itself emerging as a response to criticisms of positivists for comparing the natural world to the social world and for their insistence on separating fact from values (Mingers, 2014). The deterministic belief of positivism has also been condemned as unsuited to social science research because of the capacity of people (as social objects) to change their behaviour and learn, rendering attempts to find regularities or laws to describe social systems a 'pipe dream' (Sayer, 2000). Strong interpretivist approaches, meanwhile, have been maligned due to their focus on hermeneutics at the expense of causation, their extreme anthropocentricity and their frequent denials of the

existence of external social structures (M. Archer, Decoteau et al., 2016; Mingers, 2014; Owens, 2013; Sayer, 2000).

The research questions outlined in the introduction to this chapter are concerned with both the nature of WBWC participation in science, and how WBWC students experience different forms of engagement in formal and informal science fields. A choice between the two opposing (and extreme) paradigms discussed above would leave the research undertaken to explore said questions vulnerable to their corresponding critiques; in particular, I was conscious of avoiding implied determinism (discussed further in Chapter Three), and equally mindful of the lack of explanatory power associated with strong interpretivism (Potvin, Bisset et al., 2010). A third option, *critical realism*, presented itself as a viable alternative to these two approaches, and it was within this paradigm that this research took place. The next sub-section will outline the main philosophical positions of critical realism, and what the implications were for this research.

4.2.2. Critical realism and a 'third way' for educational research

Critical realism emerged in the latter half of the Twentieth Century in the 'post-positivist crisis' as a challenge to what was considered positivism's misidentification of epistemology with ontology (M. Archer, Decoteau et al., 2016); what Bhaskar (2008) – arguably the originator of modern critical realism – termed the *epistemic fallacy*. This was a charge also levelled at those operating within strongly interpretivist paradigms. While ontology and epistemology are undoubtedly connected, critical realists argue that we should not conflate the world and our experience of it (Sayer, 2000). Thus, critical realists claim that a realist ontology and relativist epistemology are not incompatible, and those operating within the 'meta-theory' of critical realism normally adopt these philosophical positions (M. Archer, Decoteau et al., 2016).

According to Maton (2015), educational research is 'ripe' for critical realist studies. The current 'battleground' of educational research is presented as constituting two supposedly oppositional and unsatisfying positions: that which is focussed on exploring policy issues – normally of a quantitative nature – and research exploring

subjective and social differences in education – normally hermeneutic and anti-realist in nature (Maton, 2015). Critical realists believe this false dichotomy would have researchers dismissing certain types of data based on the level of congruence with the approach they are using. In doing so, important elements of the everyday experiences of individuals could be obscured, which could otherwise provide valuable insight into the issues at hand (Vincent & O'Mahoney, 2018). Critical realism is argued to provide some remedy to this flawed dualism (Maton, 2015; Scott, 2000; Vincent & O'Mahoney, 2018).

Many critical realists adopt an anti-conflationist position, which argues for reconciling quantitative and qualitative data and suggests that either, or both, can be used if it is appropriate to the research question (McEvoy & Richards, 2006). Nevertheless, it is worth noting that although the use of quantitative data is largely accepted amongst critical realists, the extent of its value is considered to be limited in social science research. In particular, critical realists completely reject the use of statistical modelling due to the 'open-system' nature of the social world; in other words, one cannot make claims as to the *predictive* power of data in an *unpredictable* setting (e.g. a school) where all variables cannot be accounted for (Maton, 2015; Nash & Lauder, 2016; Scott, 2000). Instead, the strength of using quantitative data is its capacity to describe wider patterns which can, in turn, contribute to the search for *retroductive* explanation (McEvoy & Richards, 2006).

In order to understand retroduction, it is important to highlight how critical realists model reality vertically into three domains (Bhaskar, 1998a; Fletcher, 2017). This layered, albeit overlapping, ontology, allows us to distinguish between an *empirical* level of reality where events are experienced, observed and understood through human interpretation; an *actual* level of reality where events occur, observed or otherwise; and the *real* level of reality consisting of objects or structures (both physical and social) with the capacity for causal mechanisms that may (or may not) generate events at the empirical level (Bhaskar, 1998b; Bygstad & Munkvold, 2011; Fletcher, 2017). In the context of education research, the empirical might be represented by the observation of inequalities in uptake of post-16 science courses,

the *actual* might be events such as student behaviours or decisions, while the *real* could consist of student beliefs and prior conceptions (G. Brown, 2015).

Thus, critical realism is a 'deep realism' (Joseph, 1998), which is not interested in investigating regularities at the level of events, but to explore and hypothesise what potential underlying mechanisms produced these events (Bygstad & Munkvold, 2011). This is the process of *retroduction* and it is a key element of analysis in critical realist research, as Bhaskar (2008) explains:

> Theoretical explanation proceeds by *description* of significant features, *retroduction* to possible causes, *elimination* of alternatives and *identification* of the generative mechanism or causal structure at work (which now becomes a new phenomenon to explain). (p. xvii)

Critical realism therefore accepts there to be an external, layered reality which can be understood through theoretical exploration of a range of (appropriate) data types. This allows us to construct knowledge about the causes behind, for example, White British working-class under-representation in science without resorting to the tautological explanations offered by commonly cited factors in this area, such as unequal prior attainment (*see* Chapter Two).

Limitations of critical realism

By providing counters to the limitations of positivism and constructionism, critical realism has provided an appealing 'third way' which, as of yet, has received little direct criticism within the field of social science. When it does occur, it is often focussed either on the weaknesses of individual critical realists' arguments and theories – but framed as a critique of critical realism more generally (Healy, 1998; Joseph, 1998); or it is concerned with the field's preoccupation with philosophy, which is documented in a considerably more substantial way than the small body of literature dedicated to the empirical applications of critical realism (Cruickshank, 2010; Gunn, 1989). This latter point is perhaps reflective of the relative infancy of critical realism within the field of social science but also because of the methodological challenges presented by a paradigm which is orientated around abstract research. For instance, mechanisms are considered to be a central idea

within critical realist methodology, however, as Bygstad & Munkvold (2011) ask, "how do we identify mechanisms, since they are not observable?" (p.3).

Critical realism does not accept correlation between observable phenomena as explanation but, as mentioned above, the field is yet to provide sufficient numbers of *concrete* examples of research appropriate to the paradigm's epistemological and ontological stances. Both these issues may hinder educational researchers wishing to undertake critical realist research. Indeed, I struggled to find empirically-derived examples of causal mechanisms in my review of critical realist literature – something this thesis aims to redress. Ultimately, Bourdieusian theory provided a more substantive body of empirical research to guide my research design and, as will be discussed next, complemented the critical realist meta-theory well.

Combining critical realism with Bourdieu

Existing empirical studies of education which use Bourdieusian theory offer a pathway to explore research operating within the meta-theory of critical realism. Certainly, various researchers and scholars using Bourdieu's work have found his theories can sit well within the critical realist paradigm (M. Archer, Decoteau et al., 2016; Danermark et al., 2001; Decoteau, 2015; Elder-Vass, 2007; Lovell, 2007; Öğütle, 2015; Vandenberghe, 1999). While both Bourdieu and critical realism provide a broad framework in which a researcher can explore their own analyses and develop ideas further, using the work of an established educational theorist such as Bourdieu gives us the means and the language to see 'what is a change, what is a variation, what is the same' (Maton, 2015, p.58). Furthermore, there are a number of points where the approaches are not only in agreement, but mutually beneficial. These are discussed here.

Bourdieu and critical realism both share a similar ontological notion of a possible misalignment between appearances and social reality. The critical realist's stratified reality is congruent with Bourdieu's idea of habitus interacting with the field, whereby the social actor's 'feel for the game' (*see* Chapter Three) can be said to happen at the level of the actual (Kowalczyk, Sayer et al., 2015; Öğütle, 2015). Furthermore, in uncovering the hidden (social) reality, both approaches have the capacity for emancipation: critical realism aspires to enable the freedom of the social

agent from 'the imprisonment of false consciousness' through explanatory critique and research into hidden generative mechanisms (Yeung, 1997), while Bourdieu's theories of cultural arbitrary and symbolic violence aim to highlight the hidden ways those in power impose their rules and meaning on marginalised groups, and make them complicit in their own oppression (Bourdieu & Wacquant, 1992).

Habitus is perhaps the most common concept of Bourdieu's to be discussed in relation to critical realism, particularly with reference to discussions regarding the relationship between individual agency and social structure (Öğütle, 2015). Both provide ways of understanding latent individual action: critical realism offers *generative mechanisms* as the underlying, enduring, potential ways a person may behave when activated (Bhaskar, 2008; Bygstad & Munkvold, 2011; Pratt, 2011). Meanwhile, Bourdieu's *habitus* is the culmination of generations of a class of people's experiences within certain social fields which render certain practices and aspirations as impossible, some possible and others probable (Bourdieu, 1977b).

While Bourdieu has been accused of being somewhat deterministic (*see* Chapter Three), similarly Bhaskar's (1978) Transformational Model of Social Activity (TMSA) – which sees social structures as pre-existing human activity, which then reproduces those structures (Joseph, 1998) – has been criticised for its inattention to the possibilities of social actors *transforming* social structures (Baert, 1996). Margaret Archer, a prominent critical realist, has responded to this with a dualistic morphogenetic model emphasising the independence of society from individual actors (M. Archer, 1995; Mingers, 2014). This, in turn, has been criticised for lacking clarity on the nature of the relationship between actors and structures (Healy, 1998) and for side-lining habitual action (Decoteau, 2015).

Some scholars have attempted to reconcile the ongoing issue of structure and agency for critical realism and Bourdieu by combining the two. The most compelling of these is offered by Decoteau (2015), whose reworking of Bourdieu's theory of habitus – which already clearly outlines the relationship between structure and the individual – is improved by the reflexivity of Archer's approach. Decoteau suggests social agents are situated at the intersection of multiple social fields and are therefore capable of reflexivity. Furthermore, the habitus' layered nature (reflecting both the 'original'

habitus and the restructured, 'acquired' habitus) means that reflexive action can occur when there is tension between field positions or within the habitus itself (Decoteau, 2015).

The final point I will make regarding the strengths of combining Bourdieu and critical realism is epistemological. One of the main criticisms of epistemic relativism is that it runs the danger of claiming 'anything goes' and that only those with the best rhetoric or power have their theories accepted (Campbell, 1997; Machamer, 2002; Raskin, 2008). Most critical realists reject judgemental relativism and recognise that not all accounts are equal, although they acknowledge the tensions involved in adjudicating accounts of reality (M. Archer, Decoteau et al., 2016; Mingers, 2014). However, these issues are not necessarily problematic when using Bourdieusian theory, which analyses the reproduction of knowledge constructed by dominant groups. Indeed, as will be explored further below in sub-section 4.2.4, privileging the knowledge constructed by the oppressed can provide opportunities for their emancipation.

As with Joseph's (1998) critical realist work using Marxist analysis, Bourdieu's social reproduction theory provided the tools with which I undertook the analysis for my study, while critical realism acted as a 'philosophical underlabourer', clarifying the conceptual elements of Bourdieu's work. The following section outlines some more specific ways the critical realist paradigm informed this study.

4.2.3. A critical realist approach to WBWC under-representation in science

In taking a realist ontological approach, this research was concerned with the *nature of the reality* of White British working-class engagement with science. However, in accordance with the tenets of critical realism, it does not claim absolute knowledge of these phenomena can be known (as is the case in the positivism paradigm) (Scott, 2005). Instead, critical realism incorporates a 'modest' relativist epistemological position, which focuses not on truth or false-ness but existence or non-existence (Osborne, 1996). In other words, improving understanding of the kinds of WBWC science engagement that do (or can) exist and the conditions of their existence. Furthermore, operating within the critical realist paradigm allowed this research to accept the external reality of WBWC under-representation in formal science

education fields (*see* Chapter One), rather than believe it to be a construction, and thus to seek further understanding of the causes for why WBWC students tend to not continue in these fields. Indeed, one of the appealing aspects of a critical realist approach is the scope for explanation that is not at the expense of interpretative understanding (Sayer, 2000).

Critical realism achieves the balance between explanation and understanding by focusing on *tendencies*. In doing so, it avoids the essentialist nature of positivism, which in the context of this research would fix WBWC students' identities and their practices as deterministically producing the outcome of non-participation in post-16 science (Sayer, 1997). As Decoteau (2015) explains:

> Critical realism posits that reality is so layered, complex and conjunctural that, at best, we can only theorise about some of the *possible* mechanisms at work. Generative mechanisms exist whether they are triggered or not, which is why causality is generally discussed as a *tendency* rather than a property *sui generis* (p. 308, emphasis in original).

Thus, a critical realist approach not only allows for variance within data patterns but *expects them to appear*. It is arguable that most empirical social science research would concede such variance (whether it attempts to explain or discuss it, or not) and the research within this thesis was no exception. As will be seen in the upcoming data chapters, a small minority of WBWC participants did (at least initially) continue with their formal science studies beyond compulsory age. However, their continued participation did not belie the explanations given as to the wider pattern of non-participation. Instead, they provided an alternative route to understanding the potential mechanisms involved.

Another common key epistemological position within critical realism states that knowledge about social reality is always historically, socially and culturally situated and, therefore, fallible (M. Archer, Decoteau et al., 2016; Sayer, 2000). This is both a direct challenge to the supposed value-free knowledge claims made by positivists and an acceptance of the constructed nature of social knowledge advocated by relativists, as discussed above. The implications for this research are that the claims made here for explaining and understanding why WBWC students do not tend to participate in

post-16 science fields are relayed as a product of an historical inquiry which is contextually, conceptually and activity-dependent (M. Archer, Decoteau et al., 2016). The same claims may not be viable in the future, or, indeed, be made about the past when contexts may be quite different (Sayer, 2000). It was an aim of this research to provide a contemporary account of the structures and processes which were believed to be fundamental to the context within which participants were operating. These are discussed further in the data chapters which follow.

The fallibility of knowledge, an essential critical realist belief, was particularly helpful in reconciling any variance in individual cases. As is discussed in the following data chapters, this was not an uncommon occurrence due to the longitudinal nature of the study (when participants contradicted earlier statements they made) and, on occasion, inconsistencies between responses of students and their parents regarding the nature of their out-of-school science engagement (*see* Chapter Six section 6.2.1). Instead of looking for 'truthful' accounts, critical realism allows one to focus on whether accounts have been *distorted by ideology*. This is achieved by using historical analysis and sociological theory (such as Bourdieu's theory of social reproduction as used in this thesis – *see* Chapter Three) to move beyond the 'common sense' assumptions in the data and allow for deeper understanding of the structures and processes that may account for the phenomena involved. It is felt that the resulting understanding is of use for the academic field and for raising the critical consciousness of the disadvantaged social group under scrutiny (McEvoy & Richards, 2006; Wainwright, 1997). The social justice implications of this will be discussed further below.

4.2.4. Social justice as epistemological belief and axiological value

The research paradigms we choose as researchers reflect both the world we live in, and the one we want to live in (Lather, 1986). As mentioned at the beginning of this section, social justice greatly informed the methodology of this research. This, perhaps unsurprisingly, is most strongly seen in my moral and ethical values, however social justice was also a significant component of the research's epistemological position. In order to explore this idea further, this sub-section begins with an outline

of my axiological beliefs, followed by a discussion of the implications for epistemology.

Critical realism has been described as difficult to precisely define and it has been argued that there is no one unitary framework, methodology, or set of beliefs that unites all critical realists (M. Archer, Decoteau et al., 2016; Scott, 2005). Nevertheless – as discussed above – critical realism is generally seen as a 'moral philosophy', in that its ontological ethics are based on human well-being and emancipation (Bhaskar, 1998a; Nash & Lauder, 2016). These are the broader aims of this research paradigm; however, it is arguable that a researcher's axiological position reflects their more personal philosophical beliefs. Despite this, values and ethics cannot simply be set aside to 'objectively' pursue our work. As researchers, our values influence the choice of topic for study and the moral behaviours with which we conduct the research (Betta & Swedberg, 2017; Dillon & Wals, 2006; Lather, 1986). The knowledge, or 'social facts' we seek to generate in our research cannot be separated from values; facts are value-laden and, it is arguable, as values have an experiential basis, values themselves are *fact-laden* (Gorski, 2013).

I grew up in what is officially considered a 'deprived' working-class neighbourhood and since then have had a personal and professional interest in widening participation for marginalised youth. My axiological beliefs reflect those held by evaluators working within the *transformative* paradigm, which, it is worth noting, shares critical realism's relativist epistemology but assumes a socially-constructed ontological position (Mertens, 2007). It is felt that research can and should attempt to meaningfully contribute towards improving the human condition by both being inclusive and addressing past inequalities (Greene, DeStefano et al., 2006).

Proponents of the transformative paradigm argue that to effectively address inequality it is critical to be *culturally competent;* that is, to have respect for culture and to be aware of relevant dimensions of diversity e.g. gender, race and ethnicity, class within power relations (Mertens, 2007; Mertens & Hopson, 2006). My training within the discipline of sociology has afforded me the latter, but it is my background and upbringing which, I believe, truly enables the former in the context of this thesis. The participants who engaged in this research were initially both strangers and

familiar to me – I have known, and in some cases still know, people like them within my immediate and extended social circle. I did not view participants as passive objects of study, but as peers who generously allowed me, and previously my colleagues, an insight into the struggles and triumphs of their lived experiences. I felt that this was influential in the easy rapport I generally established with participants, and, I believe, positively affected their retention rates in the project. Of course, my background also presented some limitations in these processes, more of which is discussed further in the next sub-section.

As indicated earlier, the aim and hope of addressing the issue of under-representation of WBWC students in post-16 science fields was not only reflected in the axiological beliefs of this research; social justice also formed a significant epistemological position. I pointed out above that the criticism of epistemic relativism of 'anything goes' can be countered with the use of Bourdieusian theory, which highlights how constructions of reality reflect the differentiated positions of power of the social agents involved. However, this does not reflect a social justice epistemological belief *per se*. In order to do so, it is argued that one must privilege the knowledge constructed with participants who are frequently marginalised, such as the WBWC participants of this study. This is somewhat similar to a position taken by the transformative paradigm, which seeks to determine which ontological (constructed) reality holds potential for social transformation and increased social justice (Mertens, 2007). In producing knowledge about the under-representation of WBWC students in formal science fields with the under-represented group(s) themselves, rather than dominant groups who may be party to their marginalisation, we may redress the balance of accounts of the phenomena at hand.

4.2.5. Role of researcher

I undertook this work as an apprentice of academia, developing and honing skills while mindful of producing a novel piece of meaningful and rigorous research that would do justice to its participants. An essential component of this development was the careful consideration given to my role as a researcher in relation to the participants. As mentioned previously, I consider myself as from a White British working-class background, although this is somewhat complicated by my middle-

class (post-secondary) education and status as an academic from a university. Chapter Three discussed the dynamic nature of social class as used in this thesis, and as a researcher I was not exempted from this idea. Regardless, it is not apparent whether participants viewed me as absolutely middle-class; if they were to speak in terms of class at all, which they rarely did. As a result, I did not feel able to identify and embrace the 'we' in my writing the way Patricia H. Collins did when discussing Black women and their ideas in her seminal work *Black Feminist Thought* (Collins, 1991).

The axiological position of this work outlined in sub-section 4.2.4. stated the importance of *cultural competency* in pursuing social justice for marginalised groups. I suggested that my background and familiarity with WBWC culture helped to facilitate competency in this area while undertaking the research. Nevertheless, as indicated above, this was not as straightforward as it may seem. Sharing some similar lived experiences with participants does not allow me to claim true 'insider' status (Cooper & Rogers, 2015). When engaging with the participants I likely enacted middle-class behaviours while also referencing working-class cultural practices and values. As Symonette (Symonette, 2004) points out:

> "Presumed similarity through sociocultural invisibility — regardless of intent — is problematic… What ultimately matters is not personal *intent* but rather interpersonal *impact*." (p. 98, emphasis in original)

Thus, regardless of my beliefs of holding a prior understanding of WBWC values and cultural practices, it was essential this didn't lead to complacency. As Denscombe (2012) suggests, the 'relativist' awareness of the inevitable influence of the researcher's 'self' on their research is an exercise in *reflexivity*. In order to be reflexive, a researcher must maintain a consideration of their status as an insider/outsider as well their class, gender and ethnicity in order to understand how the feelings, values and knowledge brought to the field identified and shaped the research questions, methods and modes of analysis (Attia & Edge, 2017). I recognised that, as discussed in sub-section 4.2.4, I brought my own values and beliefs to the research. Regardless of my sensitivity to the researcher status, however, it was felt

that the fuzzy boundary between researcher and participants generally allowed for successful attendance to culture, diversity and equity (Boyce, 2017).

This section has served to outline the philosophical assumptions made in the course of this research, including a discussion of how my use of Bourdieusian theory fit within the critical realist paradigm and a reflexive consideration of my role as researcher. Such perspectives guided the methods used to undertake the research, which will now be discussed in the following section.

4.3. Research design and methods

This research was an exploration of White British working-class students' engagement with science, drawing heavily on qualitative data which was then descriptively contextualised by quantitative data sources. While the main data sets were qualitative, it cannot be said that this was *qualitative research*, a common fallacy which misidentifies data type with methodologies, methods, epistemologies, and ontologies, etc. (Biesta, 2010; Dillon & Wals, 2006; Mertens, 2012). There is no preferred type of data or method of data collection amongst critical realists, indeed, many argue that the choice of methods is dependent, or even dictated, by the research problem (McEvoy & Richards, 2006). This section will outline the overall research design, followed by a discussion and justification of the methods used.

4.3.1. Overview of research design

The research in this thesis grew out of a studentship attached to a large, longitudinal mixed-methods project called ASPIRES. ASPIRES was an ESRC-funded project investigating the aspirations of a large cohort of students between the ages of 10 and 14 and their families from a range of backgrounds with regard to science – analysing their evolving scientific interests and identities (L. Archer, DeWitt, Osborne et al., 2013). ASPIRES2 continued the study with the same data set, following the same participants from 15 to 18 years old.

I joined the project in the second phase, when participants had already been interviewed three times over the course of five years. As a doctoral researcher on the ASPIRES2 studentship, I was both part of a team of researchers working for the wider

project and an independent researcher gathering data for my own use. This had many advantages: I had a ready population of participants to sample, which meant I could start data collection and analysis early on; longitudinal interviews with those participants afforded me historical accounts of their responses on the same themes; validated research instruments were provided for me; access to large survey datasets which I would not have had the resources to obtain for the purposes of this thesis and, of course, the administrative infrastructure of the project providing organisational support.

Due to the longitudinal, large-scale nature of the project, interview questions were largely pre-set to ensure comparability across the data sets – across time points and researchers. The semi-structured nature of the interviews provided some flexibility in the interview process (*see below*), however as data collection happened very early on in my thesis – before my literature review was complete – this limited the scope for delving into my own areas of interest. For example, in retrospect I would have asked the parents additional questions regarding their perspectives towards out-of-school science engagement, or their views on scientific expertise (*see* Chapter Three sub-section 3.5.2.); particularly to tease out any apparent gendered, classed or racialised tendencies as the intersectional analysis was more difficult in this area. Furthermore, for logistical reasons I undertook most ($N = 9$) but not all of the year 11 interviews with the WBWC participants in the wider ASPIRES sample, with the remaining interviews ($N = 3$) undertaken by colleagues. This carries with it the limitation that I was unable to explore interesting or relevant areas within the three interviews I did not undertake personally. Nevertheless, the benefits of the amount of data available through being part of the ASPIRES project far outweighed these drawbacks.

Thus, the overall design of this research was tied to that of the ASPIRES project; sampling participants from White British working-class backgrounds only. A discussion of the methods used and their suitability for the research problem can be found below. First, however, is a brief outline of the research design used by both ASPIRES projects. Both ASPIRES projects were very similar from a methodological

perspective, with ASPIRES2 acting essentially as a continuation of the first ASPIRES project.

ASPIRES (phase 1)

The first phase of ASPIRES (referred to as ASPIRES1 in this thesis for clarity) combined quantitative data collected from three online surveys of a student cohort ($N = c.$ $9,300, N = c. 5,600, N = c. 4,600$) and longitudinal, qualitative interviews with students and their parents from the same cohort ($N = 92$ and $N = 78$ respectively). Surveys and interviews took place when the students were in year 6 (at the end of primary school), 8 and 9 while they were aged 10/11, 12/13 and then 13/14. The surveys were intended to capture demographic data and attitudinal data related to science. Topics included science-related aspirations, participation in science activities, science identity and parental involvement and other attitudinal data (L. Archer, 2013). There were a few free-response items, but the majority used a Likert-like scale with 5 points from 'strongly agree' to 'strongly disagree' (L. Archer, 2013; DeWitt, Osborne et al., 2013).

Students were recruited from primary schools chosen to represent all regions of England ($N = 279$), the sample chosen to roughly reflect the distribution of schools around the country by attainment and pupil eligibility for free school meals. From this larger sample population interviews were conducted with a selection of students and their parents from varying socioeconomic and ethnic backgrounds. The interview schedules were designed to further explore the elements in the student questionnaire: student topics included perceived peer attitudes towards school and school science, science-specific and general career aspirations and their main influences; parental topics included parental attitudes towards engagement with science, their aspirations for their children and the nature of advice they gave to the student participants regarding school/subject-related decisions. All interviews were recorded with audio devices and transcribed. Due to some anticipated attrition, the numbers of students participating in the first ASPIRES qualitative study dropped from 92 to 83 over the course of four years.

ASPIRES2

ASPIRES2 continued the data sets collected in ASPIRES1, again collecting quantitative and qualitative data. The quantitative data set was the result of two national surveys of young people from the same cohort as those surveyed in ASPIRES1. The first survey took place when the participants were in year 11 (*N*= c.13,000) and the second when participants were in year 13 (*N*=c.8,000), corresponding with the age of the students from the qualitative study. The large size of the surveys ensured sufficient representation from a range of social groups, including minority ethnic and low-income participants, with the purpose of obtaining a representative picture of student attitudes to science and their science aspirations. The survey covered similar topics to those within the ASPIRES1 study, with some additional questions on students' attendance of school STEM clubs and post-GCSE decisions. A copy of the year 11 survey can be found in Appendix 3.

The qualitative component of the project consisted of in-depth semi-structured interviews with students and their parents recruited and interviewed as part of ASPIRES1. Interviews took place when the students were in year 11 (*N = 70*) and again when they are in year 13 (*N* = 61). The aims of the interviews were to explore the aspirations of these students, how they have changed over time and which factors shape them. Of particular interest to me was the influence of learner identity, hobbies/interests, family capital and family habitus. The parents of these students were also interviewed using in-depth semi-structured interviews (*N* = 62 and 65 respectively) and focussed on the parents' aspirations for their children, including any advice they might offer and their priorities with regard to subject and career choice. A copy of the parents' year 11 interview schedule can be found in Appendix 3.

4.3.2. Methods and datasets

This research draws on both qualitative data and quantitative data in order to address the questions posed in the introduction to this chapter. A mixed-method approach to data collection is considered to be suitable in pursuing social justice, as qualitative data can give the marginalised a voice which may be masked by purely quantitative research, while quantitative data can demonstrate outcomes

considered credible by community members, scholars and policymakers (Mertens, 2007). Meanwhile, research which aims to mobilise social change using only a single method can lead to misleading results which, in some circumstances, can have a serious and life-changing impact on marginalised groups (Mertens, 2007). In addition, scholars believe capturing experiences in both qualitative and quantitative forms establishes 'data-trustworthiness' and more accurately represents the complexity of the social issues at hand (Lather, 1986; Mertens, 2012). This sub-section will discuss in further detail why the specific methods chosen were considered appropriate for improving our understanding of WBWC engagement and participation in science. The data sets used are outlined in Table 4.1. and discussed further below. The research questions are listed again here for convenience:

1. What is the nature of WBWC youth engagement in out-of-school science, and how does it change over time?

2. What, if any, is the relationship between out-of-school science engagement and WBWC students' participation in science A Levels?

3. What are the possible mechanisms influencing WBWC students' choice between Double Science or Triple Science pathways, and in what ways may this choice affect their ongoing science participation?

Table 4.1: Outline of data sets

Data Set	Data type	Description
D.S.1	Qual. data from semi-structured interviews	Interviews with 12 students when aged 15/16 (year 11)
D.S.2	Qual. data from semi-structured interviews	Interviews with 9 parents when students were aged 15/16 (year 11)
D.S.3	Qual. data from semi-structured interviews	Longitudinal interview data from interviews with participants during ASPIRES1 and ASPIRES2. Interviews took place with students (N = 12) when they were aged 10/11 (year 6), 12/13 (year 8), 13/14 (year 9) and 17/18 (year 13). Parents (N = 10) were interviewed when the children were in year 6, year 9 and year 13
D.S.4	Quant. data from the Likert-scale questions (*see below*)	Representative national surveys from ASPIRES project of cohort at ages 10-11 (N = 9,319), 12-13 (N = 5,634), 13-14 (N = 4,600) and 15-16 (N = 13,421).

Rather than corresponding data sets with individual research questions, each question was explored using all of the empirical data available in order to identify patterns or tendencies which could indicate what mechanisms may cause them. This process is expanded upon below, along with a fuller description of each data set.

D.S.1. Semi-structured interviews with WBWC students

The semi-structured interviews included in this thesis for analyses took place over the school years of 2014/2015, when the students were 15/16. They were conducted separately from students' parents to allow participants to speak freely and not be unduly influenced or dominated by parents' responses, which can occur in group interviews, especially given the dynamics of the parent-child relationships

(Denscombe, 2012). Semi-structured interviews are considered an appropriate method to explore complex and subtle social phenomena. In particular, critical realism expects the open system nature of social reality to be 'messy', indeed much more so than our theories about them (Sayer, 2000). The in-depth nature of the semi-structure interviews provided an opportunity to capture some of this messiness, and was flexible enough to allow respondents to develop their own ideas and speak more widely on issues raised throughout the interview process (Bryman, 2012; Denscombe, 2012). It was for these reasons I have privileged the analysis of the interview data over that of the survey data in this study, using descriptive statistics purely for contextualisation (*see below*).

There are a number of disadvantages associated with using interviews over other qualitative data collection methods, such as participant observation. These include the fleeting nature of contact with participants, how 'taken for granted' or 'undesirable' matters are less likely to arise in interviews and how they do not provide direct data about participants' experiences, but rather their 'representations' of those experiences (Bryman, 2012; Silverman, 2011). Nevertheless, the latter point is not considered particularly significant in the critical realist paradigm (*see* sub-section 4.2.2.), and the unfeasibility of being present at the particular life moments such as when students were considering their choices about future science participation meant that participant observation was not particularly suitable in this context. Observation of out-of-school science engagement would have had some merit with regard to the first research question; however, it was not within the scope of this thesis to do so, particularly given the historical nature of such engagement. Furthermore, the longitudinal nature of ASPIRES meant interviewing was a far less invasive process than participation observation, while providing greater contact time than one-off interviews (Bryman, 2012).

Interviewing the students generated reports from their perspective and enabled reflection on influences from family or other individuals/groups. Students were interviewed at a critical moment in their school career: the final year of their GCSEs, when making their post-16 choices. During their interview they were asked to reflect on the science-related choices they had made throughout the course of their school

career and whether their views on the science-related matters mentioned above had changed over this period. The result was an in-depth account of WBWC students' perspectives of science captured at a moment in time when, it was felt, their decisions would significantly influence their future participation in science (*see* Chapter Two).

The interview schedule consisted of questions designed to directly and indirectly elicit information on the respondent's views regarding school science (including their choice of Triple Science or Double Science), their out-of-school science engagement, their career aspirations, aspirations in science and the greatest influences on all of these areas. The main questions my data relies on are highlighted within the interview schedule found in Appendix 3. The extensive nature of the interview schedule provided significantly detailed individual accounts of tendencies related to science and science-related cultural capital (*see* Chapter Three), while also offering an opportunity for comparison across respondents. This was particularly useful in the process of analysis for exploring associations between out-of-school science engagement and/or Double vs. Triple science choice and post-16 science participation. Interviews lasted between 45 minutes and 1.5 hours and were recorded using audio devices with field notes taken after the interview.

D.S.2. Semi-structured interviews with WBWC parents

It was both the position of the ASPIRES team (L. Archer, DeWitt et al., 2012b) and myself that the influence of family was important in the choices young people make regarding their home and school lives (*see* Chapter Two). As such, interviews took place with parents of the participating students at the same point in the study, when their children were 15/16. These interviews obtained data regarding parents' accounts of their engagement in science on their own part and with their child, any advice they reported offering to their child in the context of science-related choices at school and their understanding of the consequences of their child's choice in subject and career plans. It was felt that data collected from two respondents in the same family would allow greater insight into the background and home environment of the student. In particular, one of the aims of the interviews with parents was to

investigate whether there were any tendencies which could be understood as typical of WBWC responses.

The collection of data from students and their parents was not intended, however, to be used as an attempt at *triangulation* between the two respondents; as discussed above in section 4.2.3. the study was not intending to discover 'truths' but to improve understanding. Thus, interviews with both parties were seen as providing multiple opportunities to explore theories regarding the possible mechanisms (such as non-engagement in out-of-school science or the choice of Double Science rather than Triple Science pathways – *see* Chapter Two) causing WBWC under-representation in post-16 science fields. Interviews lasted between 45 minutes and 1.5 hours and were recorded using audio devices with field notes taken after the interview.

D.S.3. Longitudinal interview data from ASPIRES1 and ASPIRES2 interviews

This research had the opportunity to draw upon existing data already collected with the participants from this study's sample. Semi-structured interviews had taken place with WBWC student participants (N = 12) in the first phase of the ASPIRES project by other research colleagues. Interviews also took place (largely by myself) after the main data collection period for this study, when WBWC student participants (N = 9) were aged 17/18 and in their final year of compulsory education.

The longitudinal interview data, along with the interview data collected for this study, allowed for the tracking of student participants' views on school-science choices and accounts of out-of-school science engagement throughout the entirety of their secondary education. This covered critical moments such as their transition from primary to secondary school, selecting their GCSE subjects, the period when they made their choice of Double or Triple Science pathways and the final year of compulsory schooling when making their decisions regarding entering full-time employment or additional training/higher education (for further discussion of these factors and their associations with science participation, *see* Chapter Two). It was expected that analyses of longitudinal data would reveal potential ways the various academic stages were connected (Adamuti Trache & Andres, 2008; Bourdieu & Wacquant, 1992). Semi-structured interviews had also been undertaken by colleagues with the WBWC parents (N = 10) of the student participants when the

students were in year 6 and year 9 and took place again when students were in year 13 (*N* = 8). Again, the longitudinal nature of the data allowed for the tracking of their responses to these items over the course of the child's secondary education. Interviews lasted between 45 minutes and 1.5 hours and were recorded using audio devices with field notes taken after the interview.

The use of longitudinal interview data enabled an awareness of the continuation or disruption of themes and motifs, allowing concepts such as identity and habitual behaviour to be analysed as a process rather than a one-off snapshot (McLeod, 2000). One of the disadvantages of the longitudinal interview data is the threat to validity posed by multiple researchers conducting data collection, and it has been suggested longitudinal qualitative studies can quickly lead to data saturation (R. Thomson & Holland, 2003). However, it is argued that successive interviews with a participant allow for a better understanding of that person; each time they are interviewed it is expected something new is likely to be seen, as similar elements arise in new configurations (Stanley, 1992). This places longitudinal data comfortably within the paradigm of critical realist research.

D.S.4. Representative national surveys from ASPIRES

Over the course of the ASPIRES1 & ASPIRES2 projects four large online surveys were administered, providing quantitative data to complement the qualitative interviews. An advantage of using quantitative data from large data sets is the representative nature of findings, allowing for some comparison of patterns found in the qualitative data (Silverman, 2011). The repeat surveys analysed in this study were considered representative of student cohorts rather than longitudinal (as was the case with the interviews) and were used to provide snapshots of wider tendencies at the equivalent periods of ASPIRES1 interviews (L. Archer, 2013). They were particularly useful for exploring the first research question, which sought a descriptive picture of WBWC engagement in out-of-school science over time. Relevant survey responses such as attendance of school STEM/Science clubs and frequency of out-of-school science engagement were those presented in a Likert-scale, rather than the free-response items, and as such the data used were of a quantitative nature. The descriptive statistics from the survey responses were used to contextualise findings from the

interviews, fulfilling the requirement for multi-method, multi-source and multiple data-type as discussed in this section and below, in section 4.6.

Some of the disadvantages of using quantitative data have already been discussed at the beginning of this sub-section, however some further issues are worth noting. For example, correlations or associations may be found between variables which are arbitrarily defined and attempts to make phenomena measurable can result in unperceived values affecting sometimes highly problematic and unreliable concepts (Silverman, 2011). Indeed, one of the limitations of the quantitative data used in this thesis was my creation of a composite variable of all Minority Ethnic respondents. It would have been of interest to compare the data from WBWC respondents and Black (Black African, Black Caribbean) working-class respondents, as they are both considered to be subjects of 'othering' discourses by the White middle classes (Reay, Hollingworth et al., 2007), while also distinguishing Black students from South Asian students, who have been found to be more likely to pursue post-compulsory science (*see* Chapter Two). However, due to the nature of the source data, the overall proportion of Minority Ethnic students was much smaller than White respondents (Moote & Archer, 2017); for example, the year 11 survey was made up of 20.7% Minority Ethnic students compared to 75.9% White students. As an ethnic minority, Black students made up 3.7% of the total respondents, with Black *working-class* respondents making up less than 1%. It was felt these numbers were so small any comparison would have limited value and so a composite of Minority Ethnic respondents was made which still allowed for some comparison of students' responses by ethnicity.

A final consideration of the use of quantitative data is that, as discussed above, those within the field of critical realism generally consider standard models of statistical research and analysis to be incompatible with critical realist philosophy (Nash & Lauder, 2016). This research has mitigated these concerns somewhat with the use of descriptive statistics purely to contextualise and support the qualitative findings, which are the biggest focus of this thesis.

4.4. Sampling and participants

The sample population for this study consisted of White British working-class participants from the aforementioned ASPIRES2 cohort, which had been recruited from a range of school contexts and populations (L. Archer, DeWitt, Osborne et al., 2013). This section outlines the sampling process – in particular the complexity of selecting participants from ASPIRES who fit the criteria of WBWC – and gives further detail on the individuals who participated in this study.

4.4.1. Categorising participants as White British working-class

While the ethnicity and nationality of participants was relatively easy to determine, the social class was not as straightforward. As has already been discussed in Chapter Three, social class is a contested area, with no definite boundaries or consensus on how it should be measured. While I outlined in that chapter how social class has been conceptualised in this thesis, this section will present further detail of how it was operationalised in the study with regard to sampling participants. My research used a measure informed by that used by the ASPIRES project (L. Archer, Dawson et al., 2015), which combined markers of both economic and cultural capital to categorise participants as from WBWC backgrounds.

The ASPIRES project categorised participants' social class largely based on parents' occupation, housing tenure and level of education (Francis, Archer, Moote, DeWitt, MacLeod et al., 2016). The first two items are considered reliable measures of economic capital, while the latter is commonly used as an indicator of cultural capital (Bourdieu, 1977a). In addition to parental education level, other items which informed the level of cultural capital included number of books in the home, the number of televisions and regularity of museum attendance (L. Archer, DeWitt & Willis, 2013). Participants were then categorised into five 'cultural capital level' groupings: 'very low', 'low', 'medium', 'high' and 'very high', and consequently those with low or very low levels of cultural capital and whose parents were in semi-skilled, unskilled or manual labour jobs were considered to be working-class (L. Archer, DeWitt & Wong, 2013; DeWitt, Osborne et al., 2013; Francis, Archer, Moote, DeWitt, MacLeod et al., 2016).

Thus, respondents from the ASPIRES population who self-identified as White, with British nationality and categorised as working-class were considered eligible for this research. As the resulting number of students was relatively small (*N* = 12), all were approached regardless of gender or geographical location. It was expected that of all participants in the wider ASPIRES project, this demographic would be the hardest to re-engage. While this proved to be true, interviews eventually took place with all twelve participants.

Participants were not specifically asked what they considered their social class to be, and none of the participants volunteered such information. It is a common occurrence amongst contemporary sociocultural studies exploring social class for participants to distance themselves from class labels, perhaps reflective of the contentious nature of social class. This is particularly so for those we might categorise as White working-class, due to the perceived 'spoilt' nature of the White working-class identity (Reay, 1998; Skeggs, 1997). Additional corroboration of participants' classification as working-class is detailed in Appendix 2 through evidence from interview data which highlight an apparent lack of legitimated, recognised forms of Bourdieu's three forms of capital – economic, cultural and social. This is considered to be a vital step for upholding a Bourdieusian analysis of social reproduction (Skeggs, 1997). Further discussion on participants' possible *misrecognised* forms of capital can be found in the data analysis chapters.

4.4.2. The study participants

Table 4.2. describes the sample in further detail, including the level of cultural capital attributed and the classification of parental occupation as social class indicators; age when I interviewed them at the beginning of ASPIRES2; gender; students' GCSE attainment; parents' level of education and participants' geographic location for context.

Table 4.2: Participant details (with pseudonyms)

Name	Age	Gender	Level of cultural capital	Parent occupation and educational background	Student's GCSE Attainment	Location
Bobster	15-16	Male	Low	Left school at 16, currently works as a nursery nurse	Mix of Cs, Bs and Ds with a C in Core Science and a B in Additional Science	Hampshire - suburban
Martha (Bobster's mother)	40-45	Female	Low			Hampshire - suburban
Celina	15-16	Female	Very low	Left school at 16, currently works in a betting shop	Mostly As and Bs with a B in Core Science, and a C in Additional Science	London – urban
Leah2 (Celina's mother)	30-35	Female	Very low			London – urban
Charlie	15-16	Female	Low	Left school at 16, currently works in a toy shop	Some As, Mostly Bs with a B in both Core and Additional Science	Essex - suburban
Robyn (Charlie's mother)	35-40	Female	Low			Essex - suburban
Connie	15-16	Female	Very low	Left school at 16, currently works as a dinner monitor	Unknown	Essex - suburban
Shelly (Connie's mother)	35-40	Female	Very low			Essex - suburban
Danielle	15-16	Female	Low	Left school at 16 and went to college to take a City & Guilds course and then an A Level in English, currently works as a catering manager at a school	Mix of As, Bs and Cs, with a C in both Core and Additional Science	Leicestershire – semi-rural
Sandra (Danielle's mother)	45-50	Female	Low			Leicestershire – semi-rural
Dave	15-16	Male	Very low	Left school at 16 and went to college to study Art and Design, currently works in hospitality	Unknown	Essex - suburban
Jane2 (Dave's mother)	35-40	Female	Very low			Essex - suburban
Football Master	15-16	Male	Low	Left school at 16, currently works as a learning support assistant	A few As, mostly Bs and three Cs.	Hampshire - suburban
Laura (Football Master's mother)	40-45	Female	Low			Hampshire - suburban
Hedgehog	15-16	Male	Very low	Left school at 16, currently works as a postman	They went pretty well (mentions having to change plans according to grades) Grades not confirmed.	Essex – suburban
Larry (Hedgehog's father)	40-45	Male	Very low			Essex - suburban
LemonOnion	15-16	Female	Low		All A*s-Cs, inc. A in Chemistry,	Hampshire - suburban

SallyAnn (LemonOnion's mother)	35-40	Female	Low	Left school at 16, is currently unemployed	A in Biology, B in Physics	Hampshire - suburban
Lucy	15-16	Female	Very low	Left school at 16, currently works as a customer advisor	A few As, mostly Bs with a C in both Core and Additional Science	Leicestershire – semi-rural
Florence (Lucy's mother)	35-40	Female	Very low			Leicestershire – semi-rural
MacTavish	15-16	Male	Very low	Left school at 16, currently works as a 'meals on wheels' delivery driver	Pretty good GCSEs (no grades confirmed in interview)	Essex - suburban
Marigold (MacTavish's mother)	45-50	Female	Very low			Essex - suburban
Millie	15-16	Female	Low	Left school at 16, currently works as a teaching assistant	Unknown	Norfolk – semi-rural
Sinead (Millie's mother)	45-50	Female	Low			Norfolk – semi-rural

A short biography of each student and their parent can be found in the appendices, to act as a reference point regarding participants' trajectories throughout the study.

4.5. Ethical research practices

As (Chubb, 2000) states, doing a PhD involves not only learning the nuts and bolts of designing and implementing research but also how to enact ethical research practices. Indeed, according to Denscombe (2012), being ethical is as important for a research strategy as its suitability and feasibility. The research's ethical positions were discussed as part of the axiological position in sub-section 4.2.4. but outlined here are the more general ethical research practices followed.

The wider ASPIRES project gained ethical approval through King's College London Research Ethics Committee (KCL REC), a copy of which is found in Appendix 1. Day-to-day ASPIRES activities and processes adhered to The British Psychological Society *Code of Ethics and Conduct* (The British Psychological Society, 2018). As a researcher within this project I followed the same principles; furthermore, I was able to undertake my research within the boundaries agreed by the ethical approval provided by KCL REC.

Once identified as suitable participants, parents were approached in the first instance and consent sought for both theirs and their child's participation. On occasions where communication was not possible using their held contact information, contact was

made with the student's school and consent forms sent to the school to pass on to the students. The students and their parents were made aware that, despite their previous involvement in the study, they were under no obligation to participate and were provided with an outline of the ASPIRES' project research aims as a reminder (*see* Appendix 1). Participants were also advised they could withdraw from the study up until August 2016 and that their data would be destroyed as a result. Before each interview both the parent and child signed a consent form, a copy of which can also be found in the appendices. As part of this consent form there was a detailed explanation regarding the purpose of the research, how the data was going to be used and stored, and who would see it.

Interviews were arranged in a location convenient to participants. For parents this largely took place at home, although one parent was unable to meet in person and therefore the interview took place over the phone. Student participants were either interviewed at home or at school, always with a parent or teacher in close proximity and/or visible. I, along with all my research colleagues, undertook an enhanced Disclosure and Barring Service (DBS) check before any contact with participants was made. Interview participants were invited to choose their own pseudonyms, which most did or otherwise agreed to the one suggested by the interviewer (DeWitt et al., 2012). For practical and analytical reasons, pseudonyms were also created for students' schools, as in many cases participants attended the same institution.

Interview data were audio-recorded (with participants' permission) and subsequently, as per BERA Ethical Guidelines (BERA, 2011), labelled with the pseudonyms only and destroyed from the audio equipment once transferred to the password-protected computer. Interviews were then transcribed verbatim by a professional, validated company having been anonymised by the project administrator (L. Archer, 2013). At all times interview and survey data were sent and stored using password-secured systems. Once the ASPIRES2 project is finished all audio data from the interviews will be disposed of according to the ethical guidelines of the British Sociological Association (2017), King's College London and UCL Institute

of Education[2]. Any data used in subsequent publications will continue to be anonymised.

4.6. Validity and reliability

Notions of validity and reliability have been explored already in section 4.2. when discussing the ontological, epistemological and axiological positions of the research. These two terms, while ubiquitous in research, have been interpreted with different meanings even amongst qualitative researchers (Golafshani, 2003). Most commonly, validity is considered to be concerned with, amongst other things, the accuracy and precision of the data produced, whether the data are the most appropriate for the research questions under investigation and the subsequent integrity of the findings generated (Bryman, 2012; Denscombe, 2012). The notion of validity within the critical realist paradigm is somewhat more nuanced, due to the perceived fallible nature of knowledge (*see* sub-section 4.2.3). Critical realists have argued that the difficulty lies less in the achievement of validity and more in the demonstration of it, as Wainwright (1997) notes:

> "The validity of particular research findings, be they qualitative or quantitative, ultimately depends upon trust in the researchers' integrity, at least until the research is replicated. Validity therefore refers to the techniques employed by the researcher to indulge a Socratic distaste for self-deception." (p. 12)

Reliability, meanwhile, is often described in terms of the neutrality of the research instruments used, and whether they would consistently produce the same results if repeated with similar conditions (Denscombe, 2012; Golafshani, 2003). Both validity and reliability are intertwined concepts, and in some circles have been substituted with the parallel concept of 'trustworthiness' (Golafshani, 2003; Morse et al., 2002). What they all share is an aim to achieve 'academic rigour' (Morse, Barrett et al., 2002). This section outlines in further detail the practices and techniques undertaken within the research paradigm in order to produce valid and reliable data.

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[2] Where the ASPIRES project team are now based, having moved from King's College London

This research attempted to improve understanding of White British working-class engagement and participation in science. Sub-section 4.3.2. explored how the methods chosen were appropriate for the research questions under investigation, however some further detail is required to justify the data collected. The use of triangulation through mixed methods and data sources, as was used in this research, is seen as a vital validation technique (Lather, 1986). According to critical realists, quantitative data can be a useful tool for providing indicators of the tendencies arising from causal powers embedded in real mechanisms (Modell, 2009). However, as explored further in the data chapters which follow, the survey data used in this research served to contextualise the tendencies or patterns found first within the interview data. It is believed that combining the descriptive findings of the quantitative survey responses with the richer detail of the qualitative interview data enabled this research to provide valid explanations regarding the under-representation of WBWC students in post-16 science fields. Details on the validity and reliability of the survey instrument used can be found in DeWitt, Archer et al. (2011).

Although, as discussed in section 4.2.3. and 4.3.2., the use of multiple data sources from one family were not used to triangulate the 'truthfulness' of interview participants' responses, they were valuable in providing further understanding of participants' home environments and life experiences. Inconsistencies in responses between participants on matters (such as out-of-school science engagement), when they did occur, were not seen as challenges to validity but additional data with which to strengthen, or challenge the theory used.

An additional and important strategy used in this research to obtain valid interview data was through the reflexive management of the relationship between respondents' accounts and their subsequent analysis (Wainwright, 1997). This relationship was guided by the cultural competence and respect referred to in sub-section 4.2.4. Specifically, the aim was to establish accounts which were as close as possible to the authentic views of respondents, and not distorted by the interview process. Thus, interview questions were asked in an open manner and in such a way as to not lead participants to believe there was a preferred response. Throughout the

interviews I personally undertook, responses were often summarised back to participants to enable them to critically react to my account of their world. This allowed me to check both the descriptive and interpretive validity of the qualitative data (Lather, 1986). The coding frame was iteratively developed through discussions in supervision meetings, although peer-checking of thematic coding of the interviews themselves (*see* section 4.7.) did not take place as a validity test, as the value of assessing such subjective interpretations was considered questionable (Vaismoradi et al., 2013).

The main threats to validity of this research were the potential biases involved. The longitudinal nature of the project may have positively, or negatively, influenced participants' attitudes towards the topics covered. In addition, participants were voluntary and therefore their views can not necessarily be considered as representative (DeWitt, Archer et al., 2012). However, it is felt that the longitudinal nature of the project has mitigated this latter concern somewhat, as well as addressing issues of hindsight bias. Given that the focus of this research was (under)engagement and (under)participation of WBWC students in science, recruiting participants while still in primary school meant establishing them in the project while the majority were still enthusiastic and positive about science (*see* Chapter Five). I believe that, had the research attempted to recruit the same participants when they were in secondary school, when their engagement and participation in science was on the wane (*see* Chapter Six), I would have been far less successful. This has allowed me to capture the accounts of those students who currently *did not* engage in out-of-school science, a difficult feat for many researchers (Dawson, 2012).

A threat to reliability posed by the longitudinal interviews were the different researchers which undertook them over the course of the ASPIRES project, and for the few year 11 interviews I did not do (*see above*). As was evident from the transcripts, questions were sometimes phrased in slightly different ways, and some responses were not followed up in a way that may have occurred were I the interviewer – especially given the specific focus of my research. Questions in the interviews and surveys, while largely the same, were sometimes refined or added to

over the course of time in order to improve their validity (L. Archer, DeWitt & Wong, 2013; Francis, Archer, Moote, DeWitt, MacLeod et al., 2016). However, these issues are common amongst large-scale longitudinal studies (Maltese & Tai, 2010; R. Thomson & Holland, 2003).

A final concern regarding the reliability of a longitudinal study are the effects of significant life changes in individual cases which may have indirectly, even in a small way, influenced participants' views, accounts or experiences relating to science. Several participants in my small interview sample had examples of these, with parents being seriously ill and, in some cases, dying, or parents divorcing, etc. Such events are social occurrences which may confound, disrupt or alter tendencies towards certain dispositions and practices. Changes in family structure and environment are, of course, not under the control of this research, but nevertheless this may have affected the reliability of the findings. Bourdieu spoke of the influence an individual's life history has on the habitus and distinguished the *individual* habitus from the *classes* of habitus to which an individual can also belong (*see* Chapter Three sub-section 3.3.2). This research used Bourdieu's theories to investigate habitual social behaviour related to science which distinguished the WBWC habitus from a student's individual habitus, therefore it is hoped the implications for reliability discussed above are minimal.

4.7. Analytical approach

The analysis process in this thesis has aimed to both *describe* the nature of WBWC engagement in out-of-school science and provide some *explanation* of the under-representation of WBWC students in post-16 science fields (Denscombe, 2012). Acknowledging the critical realist paradigm in which the research operated, this is framed as an attempt to improve understanding of the potential underlying mechanisms which lead to the social phenomena under observation, and as a result making practical recommendations which would transform social outcomes (Owens, 2013).

As detailed in this chapter, the data to which analysis was applied was mostly of a qualitative nature generated through semi-structured interviews, contextualised

with quantitative data derived from cohort surveys. The use of both quantitative and qualitative data helped to identify tendencies in the form of rough trends or, as critical realists call them 'demi-regularities', as candidates for further analysis (Fletcher, 2017; Zachariadis et al., 2010; 2013). The remainder of this section will explain the analytical processes of both forms of data in more detail.

4.7.1. Thematic analysis of interview data

The large amount of interview data was managed using *NVivo 11*, an industry-standard software package designed to assist with the management and analysis of qualitative data (Bazeley & Jackson, 2013). *NVivo 11* enabled me to organise transcripts by cohort and case, facilitating comparative analysis across interview years (e.g. year 6 vs year 11) and across individual participants (e.g. all interviews with MacTavish) with the use of tools such as matrices and coding queries. Interviews had been transcribed by an independent company, however I listened to the audio files while reading the transcripts in order to familiarise myself with the data and to contextualise participants' responses and to note any aural but non-verbal responses considered of merit.

When approaching the analysis of the qualitative interview data, the research took a thematic approach. While thematic analysis can be criticised for fragmenting data and abstracting issues from everyday life, content analysis which quantifies common trends was considered too reductive and lacked the nuance required, while grounded theory has been criticised as avoiding active engagement with existing theory (Fletcher, 2017; Forman & Damschroder, 2015; Hollway & Jefferson, 2000; Marks & Yardley, 2004). Coding was undertaken primarily in a deductive manner to uncover themes related to the research questions and the theoretical framework, an approach considered to be consistent with critical realism's ontology and epistemology (Fletcher, 2017). Nevertheless, some coding was also done inductively due to the lack of previous studies dealing with WBWC engagement and participation with science, and to demonstrate interpretative rigour (Fereday & Muir-Cochrane, 2016; Hsieh & Shannon, 2016).

Coding began with the earliest interview transcripts and was subsequently done iteratively and comparatively across cohort and cases. After coding each transcript, I returned to the case's earlier interviews and those of their peers to determine whether any emergent themes also occurred in the earlier data sets (Bryman, 2012). This process allowed me to expand or challenge emerging theories and resulted in coding being frequently added to, renamed, deleted or augmented. Examples of this are discussed in the next sub-section.

Initial analysis focused on how respondents talked about science, in both in and out-of-school contexts. Other areas included participants' views of science, students' position in school, references to Double/Triple Science, and parents' involvement in their child's education. While these were general themes of interest, I also undertook more specific coding using a Bourdieusian framework augmented by intersectional theory (*see* Chapter Three). The next sub-section describes this process in further detail.

4.7.1.1. *The use of Bourdieusian theory for data analysis*

The coding of the interview data drew upon Bourdieu's theories of capital, habitus and field as outlined in Chapter Three, to explore how WBWC students' engagement with science was informed by classed, racialised and gendered dispositions and their interactions. The aim was to observe particular tendencies across the interview sample in order to theorise what generative mechanisms might result in WBWC students' under-representation in post-compulsory science fields.

Bourdieu considered capital, habitus and field to be inter-related (Bourdieu, 1977b; 1990; 2010), therefore my analysis did not consider them separately from one another. Instead, my analytical approach involved looking for evidence of science-related *cultural capital* (scientific cultural artefacts and resources – *see* Chapter Three sub-section 3.3.1.1.) and science-related *social capital* (social networks with access to scientific resources – *see* sub-section 3.3.1.2) which are usually considered recognised within the *field* of school science (the principles upheld within the science classroom) and how (and if) they were leveraged through participants' *habitus* within that field.

A number of the initial deductive codes I used drew from dominant science-related cultural capital and social capital items used within the ASPIRES project's conceptualisation of 'science capital', particularly those related to out-of-school science engagement (L. Archer, Dawson et al., 2015). For example, the code 'consuming science-related media' directed me to look for examples of participants reading science reference books, watching science documentaries and engaging with websites with canonical science content. As such activities are considered to be associated with improving attainment in science (*see* Chapter Two, sub-section 2.3.2), I cross-referenced these codes with (coded) participants' accounts of their attainment in science and positioning within the school environment e.g. sets or placement in Double vs. Triple Science. This led to one of the study's key findings regarding the association between the development of general academic dispositions and ongoing science participation (*see* Chapter Eight, sub-section 8.2.3.2.).

While the science capital instrument was a useful starting point, Bourdieu's social reproduction theory had led me to hypothesise that the WBWC participants in my study were likely to exhibit relatively low levels of science-related cultural and social capital, a conjecture supported by some findings within the wider ASPIRES project (L. Archer, DeWitt et al., 2012b). This indeed turned out to be the case, with the result that I felt relying too heavily on the codes within the 'science capital' instrument ran the danger of leading me to a deficit analysis, where participants repeatedly showed that they did not generally hold science-related resources, nor knowledge of 'the rules of the game' in school science. While this process was useful to corroborate my hypothesis, it was limited in providing me with a lens for looking at what science-related resources WBWC students and their parents *did* have, and particularly what alternative dispositions they exhibited which may support a non-deficit analysis for exploring why WBWC students are under-represented in science.

This perspective led to the creation of a code for *use-value science capital*, which is scientific-related knowledge which would have personal value (*see* Chapter Three sub-section 3.5.1.). For example, many of the fathers of male participants (who generally weren't interviewed) were reported to have technical skills, usually derived

from their professional occupations, which were exhibited in the home environment and sometimes shared with their children. I also coded for examples of gendered, classed or racialised dispositions towards science. I particularly looked to Bourdieu's theories and wider literature on WBWC engagement with education for examples of classed dispositions, as well as from relevant findings within the science participation literature discussed in Chapter Two for classed, gendered and racialised dispositions, including where they intersected in their interaction with out-of-school and in-school science fields. For example, Lareau's (2011) work on classed approaches to child-rearing had highlighted that middle-class parents had a tendency to strategically cultivate their child's interests in order to develop their dominant forms of cultural capital, while working-class parents were much more passive in their child's upbringing with relation to leisure time. There were a number of examples of the latter within both student and parent interviews and instances where they were related to science were coded accordingly. A full list of the codes, including descriptions and examples, can be found in Appendix 4.

Following the thematic and comparative analysis, a rich and complex picture of participants' out-of-school science engagement materialised. Furthermore, a distinct difference emerged in the level of out-of-school engagement between primary and secondary school. It was decided that, as a result, the first data chapter would be dedicated to participants' early engagement with out-of-school science, while the second focussed on their later (dis)engagement. The final theme, informed by the third research question, was of students' accounts of belonging, or not belonging, in the elite, academic field of school science when they reached year 11. This is explored in the final data chapter, which discusses the influence of structure of Triple vs. Double science on future science participation.

4.7.2. Analysis of survey data

As discussed above, the use of statistical analysis is a point of contention amongst critical realists, although many accept that descriptive statistics are useful, and proponents of mixed-methods design argue them to be a legitimate way of summarising trends and 'demi-regularities' (Zachariadis, Scott et al., 2010). The

survey data drawn upon in this study were used to contextualise and provide background for the interview data, which was the main focus. This was done through an examination of descriptive tendencies or patterns across different year groups and between different sociocultural groups.

4.8. Summary

This chapter has outlined and demonstrated the decisions and processes used in this research to address the questions posed. The critical realist paradigm within which this research operated had a profound influence on the methods used, the ethical practices enacted, and the modes of analyses undertaken. The aim of such an approach was to improve understanding of why White British working-class students do not tend to continue participation in science beyond the compulsory age of study, and in doing so provide recommendations for practical action which could improve their representation in post-16 science fields. However, it was acknowledged that any findings and resulting recommendations would be historically, culturally and contextually situated and therefore may not be applicable across time and place.

This research used a multi-method, multi-sourced research design to explore research questions which required an in-depth exploration of WBWC students' views and relationship with science both in and out of school. Twelve students and nine parents were sampled from the wider ASPIRES project and semi-structured interviews took placed when students were in their final year of compulsory science education. Further analysis took place on longitudinal interviews with the same participants and findings were contextualised against cohort surveys from the ASPIRES project. The under-explored nature of WBWC engagement and participation in science required a narrowing down of issues, those which emerged were the nature of WBWC students' engagement with out-of-school science and the factors influencing their choice between the Double and Triple Science pathways. These findings are presented and discussed in detail in the following chapters.

5. Exploring WBWC students' early engagement in out-of-school science

5.1. Introduction

The first two data chapters of this thesis investigate the relationship between extra-curricular science activities and White British working-class (WBWC) students' ideas of whether to continue studying science once it ceases to be compulsory. As we have seen in Chapter Two, out-of-school engagement in science has been frequently cited as an important factor influencing interest in science for those who continue to study and participate in science pathways. However, less is known about what engagement in out-of-school science looks like for those who *don't* continue with science, particularly for WBWC youth. Given the denigrating discourses which surround the WBWC students and their families, an investigation into the nature of WBWC engagement in out-of-school science engagement was of interest as a contribution to knowledge but also for reasons of social justice.

These two data chapters explicitly explore the first main research question of this thesis: *What is the nature of WBWC youth engagement in out-of-school science, and how does it change over time?* They also include some discussion of the second research question: *What, if any, is the relationship between out-of-school science engagement and WBWC students' participation in science A Levels?* This question is also addressed more fully in the Discussion and Conclusion Chapter. These two chapters are divided into early out-of-school science engagement (while participants were in primary school), and later out-of-school science engagement (while participants were in secondary school), analysing longitudinal interview data to explore how this engagement changed over time. Survey data from the ASPIRES project taken at the same time periods will be presented to provide a wider context of the nature and regularity of self-reported out-of-school science activities for WBWC students compared with that of students from other sociocultural backgrounds.

This first data chapter focuses on participants' out-of-school science engagement while they were in the last year of primary school, an early but critical moment in their school career, when participants were aged 10/11. The availability of this data set provided a baseline for comparison with this study's main data set consisting of participants' views in secondary school at the age of 15/16 (more of which will be discussed in the next chapter), when they made the decision whether to continue with science in-school once it ceased to be compulsory. I will show that WBWC students' early engagement in science outside school was reported to be both widespread and varied and that a number of participants were engaged in activities strongly associated with dominant science-related cultural capital – in levels which cohort survey data indicate were comparable to students from White British middle-class backgrounds. I will demonstrate that the WBWC parents, in particular mothers, often held considerable amounts of scientific knowledge related to personal medical histories of family members, knowledge which could be recognisable as canonical scientific knowledge, regardless of its personal nature. Nevertheless, I will argue that the self-led, leisurely nature of most WBWC student participants' early engagement with science reflects classed and racialised approaches to child-rearing and that this makes students' position regarding post-compulsory science participation somewhat unsure.

This chapter reports an analysis of the year 6 student interview and parent interview data sets; the interviews are contextualised by data from the ASPIRES year 6 survey. The qualitative data were analysed with a Bourdieusian conceptual lens, informed by intersectional research, to explore patterns of participants' engagement with out-of-school science along class, gender and racial lines. The quantitative data were used to provide descriptive statistics for comparison of engagement with peers from other sociocultural backgrounds. The coding framework for the qualitative analysis, consisting of descriptions of the themes found and relevant data extracts, can be found in the appendices.

5.2. Early engagement with out-of-school science

As was noted in Chapter Two, not all outside-science activities are equal in their nature. Activities range from being more or less closely aligned with canonical

scientific culture - the 'scientific method' and/or established scientific knowledge i.e. dominant science-related cultural capital. Activities closely aligned with canonical scientific culture can both impart and represent science-related cultural capital. Bourdieu may have argued that engagement in any science activity outside of school is not enough to develop dispositions substantive to a habitus which sees future participation in science as open and of interest to them. Furthermore, students who hold sufficient science-related cultural capital of the dominant type are better placed to increase their stock of cultural capital (both specifically science-related and more generally) further and leverage it to their advantage in and beyond the science classroom (Adamuti Trache & Andres, 2008). Thus, a 'scientific' habitus, well positioned in the school science field may be dependent on *early* and *long-term* exposure to activities with strong (science-related) capital (Bourdieu, 1986). Through exploring the nature of out-of-school activities participants engaged in, a typology was developed based on how strongly an activity was associated with dominant science-related cultural capital. The typology was also informed by Ball and Vincent's distinction between 'cold', abstract forms of knowledge derived from institutions and the 'hot' personal forms of knowledge derived from personal experience (Ball & Vincent, 1998). This process was used to support my retroductive analysis of whether out-of-school science engagement could be an underlying mechanism generating ongoing science participation in science.

All of the students in the study reported doing some form of out-of-school science engagement while in primary school, and there was no mention in interviews with students of any negative experiences or associations with science in this capacity. The form of engagement ranged from a playful 'George's Marvellous Medicine' approach (e.g. taking innocuous house-hold items and mixing them together in a bowl) through to attendance of school science clubs. In using the typology, three types of out-of-school science activity emerged – *'science play'*, *'consuming science media'* and *'structured science activities'*. These are outlined further in Table 5.1.

Table 5.1: A typology of out-of-school science engagement

Type of activity	Description	Examples
Science Play	Playful, 'messy' activities around the theme of science, often unrelated to canonical science content and process	Mixing household substances without obvious consideration of which cause a reaction together
Consuming Science Media	Engagement with 'cold' abstract forms of canonical science – with a focus on conceptual knowledge over scientific practices or skills	Reading science magazines, watching scientific documentaries, etc.
Experiential Science Activities	Participating in activities which provide immediate experiences strongly associated with canonical science, particularly with reference to scientific skills but also with some capacity to produce knowledge	Using science 'kits', attending school science clubs, etc.

The three types of activity were by no means discrete and a number of participants reported engaging in all three forms. As such, some overlap occurs in the report of the activities, discussed in detail below.

5.2.1. Playing at science

The most common form of WBWC participants' early engagement with science outside of school reported was through play. Many of the twelve students reported 'messing about' with science at home while in year 6 at school, however for three of them this was their only reported engagement.

Science play tended not to be structured activities; they were not reported by the students as having a specific learning aim and it is not possible to ascertain from the interview data whether the students were attempting to build on specific scientific concepts learnt in the science classroom. The activities were normally *child-led* rather than *adult-led*, often role-playing, hands-on attempts to recreate 'fun' and 'messy' science demonstrations they had seen elsewhere:

> I know when you're younger you just kind of tip everything into a bowl and mix it… (laughs) I did that… And you make a mess and then it kind of seems…

when you see it on TV and they seem to be pouring chemicals in, you kind of think I'm doing science.

(Lucy, female, year 6)

Well if me and my sister, like we don't have anything to do, we want to do something like make cakes and see what will happen if we take this one out first, then we poke it and something like that.

(Connie, female, year 6)

When I was little I used to like, um, get like loads of different things like my dad's shaving cream, toothpaste, shampoo and mix it all up

(Charlie, female, year 6)

A number of the female participants also mentioned 'bath-bomb' science kits in their discussions regarding out-of-school science engagement:

There's these science sets you can get from Argos and that you get to like make bombs… like not actual bombs, bath bombs.

(Connie, female, year 9)

Every year I ask (my brother) for a bath bomb-maker and he always buys me the wrong one, but never mind… I said a bath bomb one, so the first thing he got me, a perfume one… I think it's a soap-maker I got the second year.

(Danielle, female, year 8)

For Christmas, I got these things like you know the Bath Bomb Factory… and Spa Factory - *they're kind of like* science stuff and like mixing stuff... The first one I make I'm going to try it out on my mum and see if it explodes.

(Charlie, female, year 6, emphasis added)

It is not clear from these participants' accounts what extent of canonical science was involved in these particular types of 'science kits', which have been highlighted as examples of promoting gender stereotypes through their pink branding and focus on make-up (Shewmaker, 2015). Participants' descriptions of their engagement with such kits aligned closely with those of other 'science play' activities, in that they involved 'mixing messy stuff together' for fun and appeared to be only tenuously linked with science. The enjoyment experienced through science play can potentially act as an important catalyst for the development of science dispositions, however the smaller likelihood of playful activities foregrounding canonical scientific knowledge or skills (*see* Chapter Two) means it is less likely to translate into dominant science-related cultural capital. Thus, it is arguable that such activities would be

limited in their potential to strengthen participants' position in the science classroom and facilitate the favourable conditions which lead to ongoing science participation.

Analysis of the parent interviews provided some insight into familial attitudes of the purpose of out-of-school engagement in science. Parents of children who only reported engaging in science play did not report particularly 'pushing' their children to engage in science activities at home and gave no indication of having knowledge of canonical scientific culture. Indeed, they often made claims to the contrary:

> I - Would you say that you are interested in (science) or (engineering)?
>
> Florence - Not really… It's not relevant to my life really. (It's) boring. I mean, obviously if (Lucy) comes home and shows me homework then, yeah, but like I say, she doesn't really discuss science much or show me much science homework so I don't really know what she does in science at school really… Yeah, so no *I don't have a vast knowledge of science* and maybe that's why me and (Lucy) don't discuss science as much as other stuff cos I just really don't know a lot about it.
>
> (Florence, Lucy's mother, year 6, emphasis added)

This account was typical of many WBWC parents in the study: science had no place in the wider family home, only as a form of child's play and as homework. Another parent, Robyn, saw science as a form of occasional leisure activity for her children, but again there was no mention of her particularly pushing science as a desirable hobby for her children to do:

> I - would you generally say that you're interested in science or not so much?
>
> Robyn - Not really, no… I mean it was quite interesting doing it at school, just to see if you added that to that what it would you know, but I wasn't really that... We've been at the (science museum) at London… Yeah, um, I mean I enjoyed it. Charlie enjoyed it.
>
> (Robyn, Charlie's mother, year 6)

Conversely, Connie's mother, Shelly, had very positive views of science:

> We all are (interested in science), we all do. We all find things very, quite intriguing. I like a question with another question… Yeah, (of) course I think life's interesting… Books, reading, wondering, life, walking around… Yeah, I love it. Yeah, I do and the girls have picked up on it… it's not the greatest thing when you want to have a nice quiet evening and then the girls, as I say, they'll

have a question and then another question. Very forward with their questions.

(Shelly, Connie's mother, year 6)

Nevertheless, despite her obvious enthusiasm for learning new things, like the other parents in this grouping Shelly appeared to have limited understanding of canonical scientific knowledge or practice and did not report pushing her children to specifically engage in activities associated with such knowledge or practice. Thus, while the parents cited above were not necessarily disinclined towards science, the home environment would be relatively unfavourable for socialising the children to develop canonical scientific dispositions, and the parents would be unlikely to transmit dominant science-related cultural capital to them. These parents appeared to be unconcerned with the idea of capitalising on their child's interest in science and were happy to leave them to engage – or not – in out-of-school science activities and usually on their own.

Lareau (2011) found similar patterns in her ethnographic study of child-rearing strategies amongst families from differing sociocultural backgrounds. Working-class families used an approach of 'the accomplishment of natural growth' enacted through large amounts of leisure time and child-initiated play, while middle-class families would be more likely to schedule multiple adult-led activities as a form of 'concerted cultivation' to develop their children's natural talents and ensure they had the 'right' types of knowledge and skills to support them in the future world of work. Lareau postulated that the middle-class approach instilled within the children a 'robust' sense of entitlement and the potential for future institutional advantages. It is argued that the same classed distinction in approaches to free time could be found in early childhood engagement in science.

Accordingly, it is argued that the WBWC children of this study who reported only engaging in science play were least likely to acquire science-related cultural capital outside of school that could be leveraged in the science classroom. Furthermore, the likelihood of the habitus of these children aligning closely with that considered most at home in canonical scientific culture is in doubt. As discussed in Chapter Three, Bourdieu asserted that habitus and capital operating in the field produces practice

(Bourdieu, 2010), therefore we would hypothesise that students from this group, when operating in the field of school science, would be in the least favourable position of choosing to study science beyond compulsory age.

5.2.2. Consuming science media

The second most common type of science-related activities participants undertook involved the consumption of science media. While most of the participants interviewed mentioned engaging in *science play*, a smaller number also spoke of consuming scientific knowledge through watching science documentaries, reading science magazines and visiting science learning websites. Such activities are argued to be more closely associated with canonical science than science play, with particular focus on conceptual knowledge rather than scientific practices and skills, aligning them with abstract, 'cold' forms of science engagement (Ball & Vincent, 1998) (*see also* Chapter Two).

As with *science play*, the consumption of science media tended to be self-led. Those who did report their main engagement with science as through such activities often talked about consuming other subject areas as well as science, either because of a conveyed intrinsic interest for learning new things or for supporting their school work:

> Sometimes I watch ... you know, like CBBC, they have like science stuff on there and they have History and it helps you and science, I think it ... I can't remember the name of it but like when they mix it together, you just know that it's gonna blow up, yeah, and it's really funny.
>
> (Celina, female, year 6)

> I watch like National Geographic and History... I think that's really interesting... Um, yeah, I've got a *World of Science* at home... a book – I was reading that and it's really interesting. It's got like how volcanoes erupt... And how like certain rocks are formed.
>
> (Football Master, male, year 6)

The students who consumed science media out-of-school appeared to have access to dominant science-related cultural capital through their engagement with legitimised sources of scientific knowledge. It has been argued that familiarity with scientific language potentially increases comprehension to improve understanding of

new concepts (Snow, 2010), thus these students should be in a good position to leverage the science-related cultural capital they have acquired through these practices to facilitate their own educational achievement. Indeed, the youth whose main engagement with out-of-school science was through consuming science media tended to be high-achieving students more generally. Nevertheless, there was little evidence in the data that they displayed specifically science-related dispositions.

Interviews with the WBWC students' parents held at the same time enable us to have a more detailed picture of the circumstances in which the students' science-related cultural capital might be generated and the extent to which their family reported being involved with developing their child's knowledge about science. Celina's father, Dave, spoke of having an interest in science through the perspective of socioscientific issues:

> I mean I'm interested in you know things, developments, you know I always keep up with (scientific) developments… I always read, I'm always interested in things improving you know… I mean on the other hand, I am concerned about… You know as they get older I mean what kind of, um, future are they going to have? You know the environment the way it's going at the moment… I mean just I'm curious about how it's going to affect them. You know if it's going to get worse or if it's going to improve over the years, whether they're going to bring all these different changes to the way we live really to improve the way you know what we have to deal with.
>
> (Dave, Celina's father, year 6)

Dave's interest in science conveys a sense of wanting to improve his general understanding of science in everyday lives, however his knowledge of dominant scientific knowledge appeared somewhat limited and he did not speak of attempting to generate an interest in science for Celina. Celina's mother, who was interviewed at the same time, did not comment. The difference in apparent interest in science between both mother and father was also evident for Football Master. Football Master's mother, Laura, initially stated she wasn't interested in science, suggesting that her son's interest in general knowledge had come from his father:

> Anything in a reference book. He's got a bit of a sponge you know *useless bits of information*… You know he's like his dad. He just holds on to history. You know he just seems to remember it and things like that. So yeah, he's probably got a bit of a flair there for it... I'd say history, not so much

geography, science, science facts. You know anything like that that he can read something about and it'll interest him. He'll sort of hold onto it

(Laura, Football Master's mother, year 6, emphasis added)

Laura did not report specifically encouraging her son to acquire science-related cultural capital – 'useless bits of information' – nor did she seem to exhibit particularly strong feelings about him learning about science more generally. Football Master's father was not interviewed as part of the project, so we cannot infer his position on the matter. However, later in the interview it became apparent that Laura had some interest in certain forms of scientific knowledge. She was particularly interested in human biology due to the *personal* relevance of the subject:

You know and the biology side of it and the human body, yes I have got an interest in that, just you know how things work with illnesses and things like that. That, yeah, I could find interesting. The rest of it doesn't really... I think when you've sort of got your children and when I was pregnant I started reading books about it. And then when you've got your children and they're sort of born with heart defects you start reading… and then my other son he's doing PE and part of that is all about the human body, muscles and things like that, so I thought oh yeah, *that is really quite interesting*. And you know like (older son) he'll throw out a little fact and you think oh yeah that's right. You know things like that, but that's about as far as it goes.

(Laura, Football Master's mother, year 6, emphasis added)

Laura's interest in acquiring scientific knowledge with personal relevance suggests that she valued scientific knowledge – or science-related cultural capital – with *use-value* (*see* Chapter Three). Meanwhile the other, male, members of her family appeared to value 'facts'; scientific knowledge which could, as Skeggs puts it, 'enhance the overall value of personhood' (Skeggs, 2004b, p.75). In contrast to Laura, her husband and son appeared to feel comfortable with science-related cultural capital with *exchange-value*.

Similar findings came through interviews with another parent-child pair. LemonOnion's only reported engagement with science outside of school while in year 6 was through occasionally watching science-themed TV programmes; she did not report doing any science play at home. Unlike Football Master and Celina, LemonOnion did not speak of an interest in science as a form of knowledge worth

acquiring. Furthermore, her interest in watching science programmes appeared to be for the entertainment value only:

> I sometimes (watch science on television). Um, what's it called … I don't know but I watch this TV science thing which most… Brainiacs… That's the only science thing I sometimes watch, *cos it's like funny all the explosions*.
>
> (LemonOnion, female, year 6, emphasis added)

This was corroborated by her mother, SallyAnn, who aside from sharing the view that the TV programme was entertaining did not report doing any science with LemonOnion or as a family:

> I - do you do any other things that are sort of related to science like watching you know science or nature programs on TV or anything like that? No, not so much. It's fine.
>
> SallyAnn - Not that I can think of. I do like Brainiac. That's sort of sciencey. If we blow up this microwave, what happens? So, I do like things like Brainiac - *the fun side of things*.
>
> (SallyAnn, LemonOnion's mother, year 6, emphasis added)

As with Laura, SallyAnn did not claim or appear to hold science-related dispositions and did not seem to encourage her children to engage in science-related activities outside of school. Nevertheless, like some of the other mothers from the study, personal circumstances meant that SallyAnn appeared to be curious about areas of human biology. While SallyAnn did not admit to 'doing' things related to science in her spare time, she did state a claim to scientific knowledge based on her history of caring for family members combined with her experience of working as a personal assistant in the NHS:

> I do like the medical side of things. Why does that happen? What happens when you do this? I do like that side of things. So, because obviously having (a son) that had a lot of medical issues and having to do I sort of learnt a bit.
>
> (SallyAnn, LemonOnion's mother, year 6)

Her experience caring for her son arguably gave SallyAnn exposure to scientific knowledge but also appeared to give her the agency to demand further knowledge from the medical practitioners she dealt with, both for the sake of her son and in her professional life.

These findings align with those from a study by Luttrell (1989), who observed effects of gender, race and class on working-class women's constructions of knowledge: White working-class women's (common-sense) knowledge was constructed by them as subjective and meeting individual needs (i.e. with *use-value*), they did not, therefore, make claims to 'legitimate' universal knowledge. Thus, Laura's and SallyAnn's similar construction of their medical 'know-how' as subjective and grounded in personal experience, rather than *legitimate scientific knowledge*, highlights the potential for WBWC students to have access to dominant science-related cultural capital in the family home, although the successful transmission of this capital is – potentially – subject to classed, racialised and gendered practices and perspectives.

SallyAnn's focus during her year 6 interview was on the use-value forms of science, however it is interesting to note that during her daughter's interview, LemonOnion appeared to have a strategic understanding of how to develop forms of science-related cultural capital with exchange-value:

> I - how can someone get to be good at science if they wanted to?
>
> LemonOnion - Um, they could do like watch TV about science, go to clubs about science if they really wanted to, and keep science when they're older in (local secondary school).
>
> (LemonOnion, female, year 6)

LemonOnion was the only participant at this point to frame achieving success in science as the result of out-of-school science engagement and ongoing science participation, which in Bourdieusian terms would be the accrual of both embodied and institutionalised science-related cultural capital (Claussen & Osborne, 2012). In contrast, her fellow participants largely framed their response to the same question as a need to work hard in school and listen to teachers. It is interesting to note that, despite having this insight, LemonOnion was the only participant who reported not really engaging in any science outside of school and, in fact, gave the appearance of being generally dismissive of such activities. Her mother, SallyAnn, did not comment on this during her interview, so it is more difficult to hypothesise as to where LemonOnion got her insights.

According to the findings from the interviews, Football Master and Celina appeared to have access to potentially significant levels of science-related cultural capital with exchange-value through the consumption of scientific knowledge as part of their everyday lives. LemonOnion also had access to science-related cultural capital but a different form; medical knowledge framed as having use-value but not seen as knowledge worth having for its own sake. All three of these students, however, did not attribute any special status to scientific knowledge and practices, and other forms of knowledge were also prized. This is particularly the case for LemonOnion, who will be discussed further in Chapter Six. The students' parents may have imparted some science-related cultural capital to their children, but they did not express science-related dispositions and did not push their children to participate in science-related activities out of school.

While these students (potentially) had dominant science-related cultural capital which could be converted into academic success in the school science field, they did not necessarily have the embodied science-related cultural capital, and therefore the dispositions to generate a 'scientific' habitus (*see* Chapter Three). Celina and Football Master's improved familiarity with the 'cold' forms of knowledge which dominate the school science classroom (*see* Chapter Two) may support the development of dispositions which recognise science as 'for them' due to science's association with educational success, but it does not appear that they have internalised dominant science-related cultural capital to the extent that they see themselves as being a 'science person'. LemonOnion's apparent disinterest in engaging with science in her spare time strongly implies she also does not see herself as a 'science person', however her awareness of the strategies one might undertake to continue with science along with her strong academic record could still potentially lead her to post-16 science participation. This suggests these three students were in a stronger position to choose to study science beyond compulsory age compared to those who only engaged in science play, but the outlook was still somewhat uncertain.

5.2.3. Experiential science activities

The final type of out-of-school science engagement by students were activities strongly recognisable as related to scientific culture, such as science kits and 'school-

like' projects done at home. These were activities which appeared to generate or reinforce canonical scientific knowledge and/or employed the 'scientific method' to investigate or explore questions participants had through hands-on, immediate experiences. In contrast to the abstract nature of the scientific knowledge consumed through different media, these science activities are associated with knowledge that is experienced first-hand.

Six of the student participants reported engaging in experiential science activities while in year 6, and many of these students also spoke of engaging in science play and of consuming science media. Of all the participants at age 10/11, these were the most likely to respond to the notion that science was one of their hobbies, and more likely to do science as a family activity:

> I just really like science. I just … it's one of them things that I don't go oh it's science. It's just one of them things I'm like quite happy to do… I've got this science book that's good. It's like a pop-out book and me and my friend… (she) really loves the book and it's really good… I've been to the space centre. The one in London it's really good, because you get to do things for yourself, like, um you get to like touch different things and move it and do things like that… I went with mum and my dad
>
> (Danielle, female, year 6)

> I go on the computer at home and I go on things to help me with maths there's that, um, it's a website and it's got lots of like sort of like experiments on there. My dad sort of likes… The Discovery Channel and we go to the (beach)… just find out about lots of different things like rocks, minerals, the sea, stuff like that.
>
> (Millie, female, year 6)

> I'm a bit of a space fan… Well, I've got books and DVDs and everything… I've been to NASA.
>
> (Hedgehog, male, year 6)

> I do like science, finding out stuff… Yeah finding out stuff and making activities and stuff… I used to want to be like a scientist and stuff like that, and loads of very brainy smart things
>
> (Bobster, male, year 6)

Four of the six students appeared to be specifically supported in their interest in science by their parents. Hedgehog's father, Larry, reported doing lots of activities

together based on his son's interest in science, apparently by a desire to do activities together as a family:

> Yeah, and we've got ... you can get like you know little science kits from the shops and there's various experiments that you know you have to do. They supply everything and then you put the things together and he likes doing the experiments at home that we done a few of them… There's been various things on the telly recently and it's just you know he's had an interest and you know we watch it together and some of the things on there are quite interesting. And you know explaining how things work and you achieve things and everything.
>
> (Larry, Hedgehog's father, year 6)

Bobster's mother, Martha, clarified the types of activities he did at home, indicating she encouraged them due to her own negative experiences in science at school:

> I was rubbish at science... Yeah absolutely rubbish. In all of it, you know just... and I don't know why. I mean I still passed my GCSEs but very, very poorly… And I literally just skimmed through. I didn't like it at all and *I think that's why I push (Bobster)* to … oh he's got a project and he'd love to do this – they made a lava lamp out of cooking oil and Alka-Seltzer. So, things like that just don't appeal to me at all, but the fact that he's interested, it was like 'That's right' you know and I'll sit down and do all of it with him.
>
> (Martha, Bobster's mother, year 6, emphasis added)

Danielle's mother, Sandra, also encouraged her to support her school science with additional science activities at home, notably combining both the consumption of media and experiential activities:

> When she had to do space a couple of months back and we went and got the books out the library for her to do that, so she could do all the like the planets from it. She did it all herself... *it's like extra homework*. And her and a friend made their own solar system and put little ... it's quite good what they did. They folded bits of paper, so you could see the difference from the sun for each one. And they just did that themselves between them. I was quite impressed with them both. What you've both done this, and you've not been asked? She said no, we just thought we want to do it. We liked it.
>
> (Sandra, Danielle's mother, year 6, emphasis added)

Sandra's quote implies she was aware that Danielle's engagement in such activities could provide her with an advantage in the science classroom. Nevertheless, despite

her interest in science and support from her mother, Danielle found herself being excluded from science enrichment activities organised by her primary school:

> When she was at (Midlands Primary School) she really enjoyed science. Although … I don't know, she didn't get on so well … she loved it, she really enjoyed it … but *I don't think her teacher was very encouraging*… you see (Danielle) as I say was really good at science… but there was four particular children in school, and every time there was a trip or something these four particular children were chosen every time. And they did a science trip to the Science Museum and she didn't even get picked for that, and yet she was the top in her class for science.
>
> <div align="right">(Sandra, Danielle's mother, year 9, emphasis added)</div>

Sandra's comment on Danielle's apparently poor relationship with her teacher implies she felt that this led to Danielle being disregarded for school organised science activities which she would have enjoyed and despite her being 'top in her class for science'. Her exclusion from these official activities would be an ongoing theme, as will be discussed in the next chapter.

In contrast to many of the other mothers in the study, one parent conveyed a personal interest in canonical scientific knowledge and current scientific research, suggesting a preference for science-related cultural capital with exchange-value:

> I am (interested in science), and but at the end of the day I'm not really interested in understanding the nitty gritty of it. I really am not. Um, *I'm just sort of into understanding the basics of what it is and how it works*… We (watch science programmes) all the time and (Millie) does with us... I will always have an avid interest in any new science or any new find or you know sort of thing. I do, I find that really fascinating, I really do.
>
> <div align="right">(Sinead, Millie's mother, year 6, emphasis added)</div>

Sinead conveyed demonstrable science-related dispositions and it appeared she was keen to pass this on to her children, although the quote above appears to show she wanted to demonstrate an overall interest in the area, rather than suggest she had *scientific expertise*. Nevertheless, her interest in science would seem to create an environment where her daughter, Millie, would be in an advantageous position to develop science-related dispositions herself, and consequently a habitus at ease in formal science fields.

Two of the six participants who engaged in activities strongly associated with dominant science-related cultural capital were not encouraged in their interest by a parent. Instead, their participation was facilitated by someone outside of the immediate household:

> There was this thing called *Horrible Science* out and my auntie got it for me. And I used to do all these experiments… but now we've used up all the stuff… So, we can't do it anymore.
>
> (MacTavish, male, year 6)

> My friend, he sort of like sits there all day on science programmes watching them. 'Let's play on my game' and he goes 'No, I'm watching science'… He's stuck onto it. He tries to show me all this stuff… he really likes science… And he taught me how to make like an ice cube… Cos you know it sinks? To float it on the top.
>
> (Dave, male, year 6)

Both Dave and MacTavish spoke positively of science, and Dave in particular seemed to enjoy the social aspect of engaging in science with his friend. However, their participation appeared to be contingent on the involvement of other people. For Dave, it was his friendship with a neighbour, for MacTavish it was for as long as the science kit his aunt bought him lasted. Their mothers, much like many of the participants in the first two groups, did not particularly encourage them to undertake any science activities at home. Marigold, MacTavish's mother, did not claim to do any science at all with MacTavish:

> I - Do you ever have science books or magazines in the house?
>
> Marigold - Me personally, no.
>
> I - Do you ever watch science programmes on TV?
>
> Marigold - I have to say I'm not really a TV person, I don't watch an awful lot of it at all.
>
> I - Have you ever been to a science or a natural history museum with him?
>
> Marigold - Um, they've been to museums with the school, but I haven't taken them.
>
> (Marigold, MacTavish's mother, year 6)

Dave's mother, Jane2, likewise did not particularly encourage him to undertake any science activities at home, but did occasionally take him and his siblings on visits to the science museum:

> When I went to school I did, I enjoyed (science). Um, I suppose in everyday life you don't get that much really to do with it now. I mean obviously with his schooling I will get more into it… The Science Museum we go to a lot actually, so yeah in the holidays… He likes that… I tend to go to the Science Museum a lot, because I like it there because you can do stuff. Whereas the other museums are a bit more just looking, isn't it? And yeah, and I like it there. You get involved.
>
> (Jane2, Dave's mother, year 6)

It was not uncommon for families who lived in or very close to London, as was the case for Dave's family, to report visits to the science museum (free entry meant admission was not an obstacle for them) with the expectation that the hands-on activities there would amuse their children. Other families from the study lived too far away to enjoy the free museums of London, such as MacTavish's. As Nayak & Jeffrey (2013) observe, Ethnic Minorities and the White working classes are fixed to their localised place and do not have the capital (or habitus) to move about, unlike their White middle-class counterparts. For Jane2, who did have localised access, other museums with more traditional exhibitions 'just for 'looking' were less appealing as they required additional effort for engagement, perhaps involving the deployment of and comfort with cultural capital she did not have.

The less guided approach to child-rearing, as evidenced by Jane2, Marigold and generally the parents from the first two groups, echoes Lareau's (2011) findings that working-class parents do not tend to view their child's leisure time as their responsibility. They draw boundaries between their home activities and their children, leaving their child to operate freely within those limits. While the other four students who engaged in this study were encouraged and supported by their parents to further their interest in science out of school, Dave's and MacTavish's positions were much more precarious.

Of all the participants in this study, it is argued the students who engaged in experiential hands-on science activities at home encouraged by parents would be the

most likely to develop science-related dispositions. The above testimonies appear to show that the parents played an important role in giving their children access to science resources within the home and showed some awareness of the potential for such activities to be leveraged in the science classroom. Thus, it is argued that the students of this group were in a position to acquire *embodied* science-related cultural capital over time through interacting with their parents and informal science education (Claussen & Osborne, 2012), suggesting that these four students would be the most likely group to establish a 'scientific habitus' and see themselves as a 'science person'. Furthermore, these parents' facilitation of their child's engagement in science served to illustrate their *advocacy* of science (Lyons, 2006), with the implication that, for these participants, engagement in science did not (at this time) overtly conflict with their ideas about what people from WBWC backgrounds normally do.

The interview cases presented above provide an in-depth description of the nature of a small number of WBWC students' early out-of-school science engagement. In order to descriptively examine patterns emerging on a wider scale, the next section looks to the year 6 cohort survey. These data are used to contextualise the findings from the interviews, including a comparison with respondents from other sociocultural backgrounds. Patterns from both sets are analysed further below, in sub-section 5.4., which discusses the implications of the findings for WBWC students' ongoing science participation.

5.3. Patterns of out-of-school science engagement in the ASPIRES year 6 survey

The ASPIRES project conducted an online survey when the interview study participants were in year 6, receiving nearly 10,000 responses, 2588 of which were identified as from White British working-class respondents. The gender profile of this population was evenly split, with 1297 respondents identifying as female and 1289 identifying as male. Respondents were asked a series of questions related to their career interests and their experience of science both in and out of school. One of these questions asked how regularly they did the following science-related activities in their own time: *Do science activities (e.g. science kits, nature walks, do experiments)*; *Read a book or magazine about science*; *Visit web sites about science*;

Visit a science centre, science museum or zoo; *Watch a TV programme about science or nature*. For each activity type, respondents were requested to report the regularity of their engagement according to the following criteria: *At least once a week; At least once a month; At least once a term; At least once a year; Never.*

Table 5.2. shows the percentages of those who reported regular engagement in these activities (those who responded *at least once a week*). The table also presents the percentages of those respondents who reported minimal engagement in these activities (those who respondents *never* to all of the activity items listed). In particular, I was interested in observable trends when comparing responses by gender (F/M), class (WC/MC) and ethnicity (WB/ME). Thus, as previously, WBWC is used to denote White British working-class, while MEMC signifies Minority Ethnic middle-class, and so on.

As discussed in the Chapter Four, the limitations associated with quantitative data do not allow me to gauge nuance within the responses. For example, the composite Minority Ethnic variable does not differentiate between, for example, Black students and South Asian students, whose families may have quite different approaches to managing leisure time. There is also no detail to discern how closely the activities reported were related to canonical science and therefore whether some of them, for example, could be defined as 'science play'. Furthermore, if a respondent indicates that they 'never' engage in any of the science activities listed, this does not necessarily mean they never engage in out-of-school science at all. For example, they may interpret the range of activities presented in the questions as not covering the type of science activity they engage in, or they may engage in lots of these types of activities but do not consider them to be 'science' (*see discussions on Laura and SallyAnn,* sub-section 5.2.3). For this reason, their engagement is described below as 'minimal'. These points – and the critical realist perspective I have adopted – caution me from inferring anything beyond a description of the statistics presented. Nevertheless, the survey responses allow me to look for wider patterns related to the interview data, and thus I have grouped the media-related items together and the experiential science activities together. As no statistical tests for significance were

run, any claims relating to differences are only descriptive and based on visible differences in the raw percentages of the responses.

Table 5.2: Percentages of year 6 students reporting regular vs. minimal engagement in out-of-school science engagement

Activity type		Sociocultural group							
		WBWC		WBMC		MEWC		MEMC	
		F	M	F	M	F	M	F	M
Consuming science media	*Read a book or magazine about science*	13.1	14.9	13.5	14.3	24.5	26.9	22.2	30.3
	Visit web sites about science	12.9	10.7	10.8	10.9	24.8	21.6	25.9	26.1
	Watch a TV programme about science or nature	31.0	37.1	31.1	36.8	35.0	40.8	36.1	46.2
Experiential science activities	*Do science activities e.g. kits, nature walks, experiments*	17.2	17.8	15.8	16.4	22.1	24.7	21.4	26.1
	Visit a science centre, science museum or zoo	2.4	2.2	1.1	2.1	5.5	4.5	3.4	4.0
Never engaging in any of the above activities		64.0	64.6	53.3	54.4	57.9	57.7	52.1	43.9

Table 5.2. shows that *watching TV programmes about science or nature* was by far the most common 'regular' science activity for all respondents, while *visiting a science centre, science museum or zoo* was the least common. This is unsurprising, given the relative ease of access to TV compared to the more restricted access to museums and zoos (*see above*), as well as more general practical constraints which can limit weekly excursions to science institutions (L. Archer, Dawson et al., 2015).

Across all activities there appears to be a trend of more male respondents reporting regular engagement in each activity than their female peers within their respective sociocultural group. There is also an observable trend of more Minority Ethnic respondents reporting regular engagement in *each activity* than their White British peers. This is particularly noticeable in the 'colder' forms of science engagement: for example, 24.5% of MEWC female respondents reported reading a book or magazine about science at least once a week, compared to 13.1% of WBWC female respondents. Meanwhile, the findings suggest that White British respondents tend to engage more in practical, hands-on forms of science activities than 'cold' activities on a regular basis. Working-class respondents reported similar levels of regular

engagement to their middle-class peers, thus class does not appear to be a factor for WBWC students in this respect.

The percentages of those who responded 'never' engaging in any of the listed out-of-school science activities describe a slightly different picture. Here, a trend appears of working-class respondents being more likely to report never engaging than their middle-class peers, while the Minority Ethnic responses appear to be close to White British responses, and the male and female responses appear to be very similar – except for the MEMC students. What is particularly striking is that the WBWC students (of both genders) are the sociocultural group noticeably most likely to report minimal engagement in out-of-school science activities (c. 64%), while the MEMC males lie at the opposite end of the spectrum, with 43.9%, compared to the other groups who sit more or less in the middle (52.1% – 57.9%).

The findings from the year 6 survey strengthen those from the interviews discussed above by providing some comparison between the sociocultural features described. Combined, they constitute a valuable component of the retroductive process, which seeks to theorise what structures or mechanisms may have caused the patterns and tendencies described above to manifest themselves within the empirical data (Bhaskar, 2008; McEvoy & Richards, 2006). The finding of similar percentages of both working-class and middle-class respondents who reported *regular* out-of-school science engagement, yet more working-class respondents tended to report *minimal* engagement in out-of-school science activities suggests the following: social class takes a bigger role in the mechanism generating WBWC students' early engagement with out-of-school science activities than the mechanism which generates which *types* of activities they undertake *when* engagement takes place. It is appropriate to take this somewhat complex relationship into account when theorising the relationship between WBWC students' early out-of-school science engagement and their ongoing science participation, which is discussed in the next section.

5.4. Exploring relationships between WBWC students' early engagement in out-of-school science activities and future science participation

Drawing from both the in-depth year 6 interview data and the broader scope of the year 6 cohort survey data, this section aims to further explore the relationships between the nature of WBWC students' early engagement with out-of-school science and their intentions for future science participation.

Despite reporting a wide range of early engagement in extra-curricular science activities, the WBWC students at this stage were largely positive but non-committal about their intentions to continue studying science:

> It *depends* how fun it is, because if I can do explosions then I'll carry it on, but if it's just like writing like what we're doing here then I'd probably not do it.
>
> (Charlie, female, year 6, emphasis added)

> It kind of *depends* what I've done through my high school years, because if I'm really interested in all the liquids and chemicals I might carry on and be an overall teacher and I'd like to do more in science, but, um, if I hadn't really enjoyed my science in high school I don't think I'd have liked to carry on
>
> (Lucy, female, year 6, emphasis added)

> It *depends* like if I think I've learnt everything about science that I've done.
>
> (Connie, female, year 6, emphasis added)

> I don't know what it's like and I don't know that I'll like it and so I *might* keep going, doing it.
>
> (Celina, female, year 6, emphasis added)

> I'm not sure. It *depends* on how I feel about it when I'm older, but science is quite an interesting subject to learn about, so from my point of view now, I think I'd keep it up.
>
> (Millie, female, year 6, emphasis added)

> I don't know, well, it's kind of hard to say right now, because when I get into secondary school it'll be like what we're doing there. But yeah, I think I *might*.
>
> (Hedgehog, male, year 6, emphasis added)

> Yeah I might. *Probably* will, because that's one I pretty much most enjoy.
>
> (Football Master, male, year 6, emphasis added)

> Yeah I'd *probably* keep going on with it… Because in secondary school you get more involved I think.
>
> (MacTavish, male, year 6, emphasis added)

LemonOnion, whose engagement in out-of-school science was minimal, was the most negative of all respondents, although she did not absolutely rule it out:

> I'm *not sure* really, cos when my brothers went (to secondary school) they said science got boring.
>
> (LemonOnion, female, year 6, emphasis added)

Interestingly, the males of the study were much more likely than females to say in year 6 they would 'probably' continue with science in the future, suggesting that differences of gender were beginning to emerge. Meanwhile, the only three students to speak confidently at age 10/11 about wanting to continue with science were Danielle, Bobster and Dave:

> Yeah, (I'll) definitely (keep science)... Because I really enjoy doing science.
>
> (Danielle, female, year 6)

> Yeah, because when you get to that stage, the science that you can do will be immense. (?) Like you can actually do like... like mixing stuff and just creating.
>
> (Bobster, male, year 6)

> I - do you think then that you would keep on studying science?
>
> Dave - Yeah. Because I like it - it's like my third choice to do.
>
> (Dave, male, year 6)

Danielle, Bobster and Dave belonged to the group which reported doing hands-on, experiential science activities out of school while in year 6. Danielle 'definitely' wanted to keep studying science, contrasting strongly with her female peers who tended to say their choice would be dependent on whether they would enjoy it at secondary school – even Millie, whose mother showed a special interest in science and made sure as a family they did lots of 'sciencey' things together, stated that science was '*quite* interesting' to know about and subsequently *might* choose science. This suggests that Danielle's extensive engagement in science outside of (primary) school, combined with her intrinsic interest in science, manifested dispositions which produced a habitus that her as a 'science person'. The implication is that female students from WBWC backgrounds who express an early intrinsic interest in science and are enabled by a key family member to engage in a range of science activities outside of school are more likely to be positive about continuing to

study science than female students who do not express an intrinsic interest in science, regardless of the types of activities they might do.

I have argued that, of the three activity types, parental-supported engagement in *experiential science activities* provides the most compelling opportunity for WBWC students to develop the sorts of cultural capital which could sustain students' participation in science beyond compulsory age. This is due to the close resemblance between such activities and canonical science or *dominant science-related cultural capital*; the capacity of these experiential activities to facilitate students' embodiment of this cultural capital as scientific dispositions, and thus see themselves as a 'science person'; and their parents' advocacy of science demonstrated through the facilitation of their science engagement, which validates science as something 'people like them' i.e. from WBWC backgrounds, engage in. In other words, regular (and long-term) engagement in science activities with family members may result in the internalisation of a durable disposition within the student's habitus which puts engagement – and ongoing participation – in science as within the limits of possibility for them.

However, participants did not solely engage in one type of activity, and it is arguable that those who engaged in both the experiential science activities and the 'cold' consumption of science media were in a stronger position to develop a scientific habitus *and* accrue the types of scientific knowledge that are recognised in the science classroom, and thus continue with science post-16.

Based on the findings from the year 6 interviews and the student cohort survey, the role of sociocultural factors in the relationship between WBWC students' early out-of-school science engagement and intentions towards their ongoing science participation appears at this stage to be less related to a difference in the *type* of out-of-school science activities WBWC students undertake, and more to whether they are likely to be influenced by their parents in their intentions. Other studies have shown that the significant involvement some (particularly middle-class) parents have in guiding and encouraging their children to undertake certain enrichment activities in their leisure time also occurs at a school-level (*see* Chapter Two). Whether the *early*

nature of students' out-of-school science engagement is an important factor remains unclear and will be discussed more in the next chapter.

5.5. Summary

This chapter has presented interview and survey data to explore WBWC students' early engagement with out-of-school science. The interview participants' early science engagement was categorised as three different activity types: *science play*, *consuming science media* and *experiential science activities*. The categorisation was based on how closely the activities were associated with canonical science or, in Bourdieusian terms, dominant science-related cultural capital, an approach which appears to be the first of its kind. It was argued that, of the three types of out-of-school science activities, the experiential science activities were the most likely to be associated with ongoing science participation. In support of this argument, participants who mainly engaged in science play or consuming science media demonstrated relatively weak commitment to ongoing science participation compared to those who spoke of engaging in experiential science activities. Nevertheless, the close association between 'cold' forms of knowledge and the scientific expertise recognised in the science classroom suggests that actively engaging with both cold and experiential forms of scientific knowledge and practices would put students in the strongest position to continue their science studies. The year 6 cohort survey data indicated WBWC students' early out-of-school science engagement was similar to students from middle-class backgrounds but different to Minority Ethnic students who were much more likely to engage in all types of activity, but particularly those associated with the consumption of 'cold' conceptual knowledge.

The availability of parent interviews afforded an opportunity to explore the role of parents in facilitating WBWC students' out-of-school science engagement. Three of the mothers held substantial amounts of science-related cultural capital with the capacity for exchange-value, but they tended to frame their scientific knowledge as 'personal' or 'basic'. Therefore, the likelihood of this capital being leveraged for their – or their child's – benefit beyond the field in which the capital was cultivated appears uncertain. These findings suggest a correspondence between cold, abstract forms of

scientific expertise and science-related cultural capital with exchange-value, while the 'hotter' first-hand forms appear to relate to science-related cultural capital with use-value. This is seen to be a vital clue as part of the retroductive process to explore the under-representation of WBWC students in post-16 science and will be explored further in the Discussion and Conclusion chapter.

Several of the parents took an active role in their child's early engagement in science, usually those who engaged in experiential science activities. It was argued that this was important both for the facilitation of students' engagement with science out-of-school and in providing recognition within the home sphere that engaging in science is normal, although the viability of WBWC students' internalising such experiences as durable dispositions would likely be dependent on this happening on a long-term basis. This was considered to be another important clue in understanding the role of out-of-school science engagement for WBWC students' ongoing participation in science.

Nevertheless, the majority of parents tended to leave their children to their own devices, in line with earlier studies which argue that children from White working-class families tend to have more autonomy over their leisure time than children from other backgrounds. The data suggest they did not actively encourage their children to engage in specifically science-related activities, especially those with a strong relation to dominant science-related cultural capital. More generally, they did not demonstrate a desire to cultivate science-related dispositions in their child, nor discuss the value of doing out-of-school science activities in supporting their child's formal science education. This was argued to explain findings in the year 6 cohort survey data, which showed that WBWC students were the group most likely to report 'never' engaging in any of the out-of-school science activities listed.

The WBWC tendency towards unsupervised out-of-school science engagement means that WBWC children are less likely to recognise the exchange-value of such activities compared to families with greater levels of cultural capital and the dispositions to apply this capital to their advantage (L. Archer, E. Dawson, A. Seakins & B. Wong, 2016). The WBWC parents' classed and racialised approach to out-of-school leisure time suggests that, on the whole, the WBWC students' long-term

position in the science classroom was more precarious than that of their middle-class and Minority Ethnic peers, whose families would be more likely to engage in practices which expose them to the forms of cultural capital which would facilitate success in science. This hypothesis is explored further in the next chapter, which details WBWC students' out-of-school science engagement in secondary school as reported from interviews when they were aged 13, 14 and 16, and explores the implications for their ongoing science participation.

6. 'I do enough science in school' – WBWC participants' engagement in out-of-school science during secondary school

6.1. Introduction

The second data chapter of this thesis reports the changing nature of White British working-class (WBWC) students' engagement in out-of-school science throughout secondary school and explores the possible impact this had on their ideas of post-compulsory science choice. The previous chapter reported that participants' early engagement in out-of-school science was widespread and varied, with several participants already demonstrating science-related dispositions. At this point participants generally held favourable views regarding future science participation, although most were cautious in expressing any certainty on the matter. As discussed previously, existing studies have claimed that a large majority of those who do choose to follow science pathways have considered doing so before the age of 14 (The Royal Society, 2004); therefore, one could hypothesise that the study participants who spoke favourably and confidently about having an interest in a scientific career before the age of 14 would be in the most likely position to persist with science post-16, particularly if their engagement in science outside of school continued to enable the development of science-related dispositions.

This chapter describes participants' later engagement with out-of-school science and gives an account of participants' reported decisions of whether or not to continue with science post-16, discussing the possible influence of their out-of-school science engagement in these decisions. I will show that while participants continued to speak favourably about science, their out-of-school science engagement diminished significantly after primary school to the point that their only reported engagement was occasionally watching science TV programmes. The trend of WBWC disengagement was also found in the survey data which pointed to a mechanism which was strongly classed, with some gender and race differences, resulting in the WBWC students being the sociocultural group most likely to report minimal out-of-school science engagement during secondary school. Meanwhile, strong classed,

racialised and gendered differences meant that a minimal number of White British working-class female respondents (1.4%) reported engaging in their school science/STEM clubs when they were known to be available, suggesting that WBWC girls occupy the least privileged position in *school-like* science fields in comparison to students from other sociocultural backgrounds, and in particular middle-class males.

Analysis of the interview data found that gendered, racialised and classed behaviours were activated in adolescence which were far less apparent when participants were interviewed in primary school (*see* Chapter Five). It is argued that, as WBWC parents gave their children even more autonomy in managing their own leisure time, students' emerging adult identities were left to grapple with the question of whether out-of-school science activities were suitable for people 'like them'. This resulted in participants experiencing a habitus 'in tension', which most appeared to try to resolve by presenting themselves as aligning closely with traditional WBWC dispositions, such as physical masculinity for boys and hyper-femininity for girls. A minority – two male participants – resolved the tension by *distancing* themselves from traditional WBWC dispositions, instead aligning themselves with White middle-class intellectual masculinity. It is argued that this was due to the sense of 'naturalness' of such dispositions for engagement in their school science/STEM club. This 'naturalness' also resulted in two female students indicating that their school science/STEM club wasn't 'for them', when they were otherwise interested in continuing their engagement in out-of-school science. A final participant, LemonOnion, appears to have resolved her 'habitus tug' by keeping her academic school identity and her practical home identity completely separate.

The chapter ends with a discussion of the relationship between out-of-school science engagement and ongoing science participation, concluding that WBWC parents' classed and racialised approaches to upbringing and their values regarding knowledge are reproduced within their children during adolescence, to the extent that they begin to dismiss science engagement, both in and out of school, as inappropriate for people 'like them'. This was particularly the case for the females of the study, who demonstrated poor self-confidence and a lack of entitlement in school-like science fields.

This chapter reports an analysis of the year 8, 9 and 11 student interview data sets, and year 9 and 11 parent interview data sets, which have been contextualised by data from surveys obtained at the same time. Interview data were again analysed with a Bourdieusian conceptual lens, this time to explore changing patterns of engagement with out-of-school science of the groups along class, gender and racial lines. The coding framework for the analysis, consisting of descriptions of the themes found and relevant data extracts, can be found in the appendices.

6.2. Diminishing out-of-school science engagement

The first data chapter reported widespread early out-of-school science engagement by the WBWC student participants. However, interviews with these participants once they were in secondary school revealed their involvement in out-of-school science decreased significantly to the point where most of them reported only occasionally watching science TV programmes. Most WBWC student participants considered themselves to have 'grown out of' or appeared to be ambivalent towards out-of-school science and this sentiment was accompanied by a predominant view of science as a school subject only. This section discusses these cases in more detail, in order to explore the nature of this later dis-engagement with out-of-school science and to identify aspects which would contribute towards a theoretical investigation of the causes behind WBWC under-representation in post-16 science fields.

6.2.1. 'Growing out of science'?

When interviewed in year 8 and year 9, a number of the student participants began to explain their declining participation in outside-school science as due to its 'childish' nature. Now they were in secondary school and entering adolescence, many of the students saw the science activities they used to enjoy as too 'young' for them:

> I used to but now I think I didn't watch (Brainiac) for a little while and then I didn't watch it from then… cos I got older, I didn't really like to watch them things then.
>
> (Connie, female, year 8)

I had like science kits when I was little and that and just experimented because it was fun, yeah… Well I just think I've grown out of it a bit now, yeah.

<div align="right">(Hedgehog, male, year 9)</div>

MacTavish - I used to get these science books with my auntie… and we used to like do the experiments that occasionally they gave us.

I - And you don't do that so much anymore.

MacTavish - No, because I've kind've matured now. I still would do it but they don't do them now do they. I don't think they do.

I - I don't think there have been any new ones so if you had them before and you've done it then you've kind've done them.

MacTavish - Yeah, cos I used to get like the one every week.

<div align="right">(MacTavish, male, year 8)</div>

Connie and Hedgehog appeared to have taken the view that science activities and popular science television programmes were too childish for them, while MacTavish seemed to imply that the age-recommendation of the activities themselves was what ruled them out. As is apparent from the above quote, he says he would have happily persisted engaging with the science kits if he had continued to have the opportunity, yet he appeared to reconcile himself to disengagement based on somewhat arbitrary age-related guidelines. MacTavish's out-of-school science engagement had always been precarious (*see* Chapter Five), now his hands-on science engagement appeared to have ceased completely.

Similar findings occurred amongst four other participants, who all reported disengagement with out-of-school science, although they were not as emphatic as their peers about being 'too mature' when asked whether they did such activities:

Not really, because a lot of the things in science you've got like ... you have to have special things and... but depending on the thing, I know I could push myself to do something like that, I could try and ask my mum and dad to come and help me, but no I haven't done anything.

<div align="right">(Millie, female, year 8)</div>

Um ... I don't know, I don't think so, I can't really remember. I remember in year 6 I did.

<div align="right">(Dave, male, year 9)</div>

I've been to the Science Museum twice and I like going there, it's fun, it's like exciting… And like every time I go there, there's something different, something new to do, but yeah, I haven't been there in like years.

(Charlie, female, year 8)

I'm not that interested in science outside of school, it depends what subject I'm at. Cos all the different subjects in science, some can interest you and some you can think 'I'm not too sure on this'.

(Lucy, female, year 8)

Nevertheless, after further questions these students reported not completely abstaining from out-of-school science engagement. All of the students acknowledged (when specifically asked) that they occasionally watched science TV programmes, although some were keen to convey that they were often too busy with other things to watch TV:

Tech and stuff… *The Gadget Show*, that's always interesting… I don't really watch TV, I'm more active. I normally play out the front with my mates and that stuff.

(MacTavish, male, year 8)

I like watching like stuff to do with tornadoes and stuff and that has a lot of stuff like scientific stuff about it, so I like to watch them, like if one's on I'll be straight in front of the telly watching it.

(Connie, female, year 9)

(I sometimes watch) like documentary programmes, like *How It's Made* and that… Yeah, actually it's cool, I watch like how stuff's made and that.

(Hedgehog, male, year 8)

I watch that *Frozen Planet* thing… I like watching that, it's quite… But I don't like it when they come and eat the pretty little animals, I'm like 'noooo'.

(Charlie, female, year 8)

Sometimes I think it's called *How It's Made* I'm not too sure… Yeah, so I sometimes watch that, yeah.

(Dave, male, year 9)

I don't really watch TV to be honest… I'm often round my friends and my music just becomes a big part of it but *because they're older than me, I can have quite mature conversations with them* and I prefer to do that than sit watching some of the rubbish people watch nowadays like *TOWIE* or rubbish… But when we watched … we watched a nature documentary in Geography I think about polar bears… and I was actually surprised that I've

remembered all of it. Because some things you see on TV and you just remember it, so I don't often put my documentary channel on but if I'm scrolling through the channels and I see something…

<div align="right">(Lucy, female, year 9, emphasis added)</div>

Well my mum and dad have always liked documentaries. I think I said that last year and they do. I haven't watched a lot, like since the last time I spoke we haven't watched a lot, but sometimes like things about stars and how the cosmos works and things like that but apart from like, I'm not sure what they're called, legends of like things like the Bermuda Triangle, but… I'm not even sure if that's got to do with science, that's more like gravity and things but no not really.

<div align="right">(Millie, female, year 9)</div>

The popularity of watching science TV programmes as discussed in the previous chapter makes it unsurprising that students still report doing so as they get older, especially as it remains an accessible source of science-related engagement (DeWitt & Archer, 2017). Nevertheless, their emphasis on doing other things than science suggests many of the WBWC students appeared to be conflicted about whether out-of-school science activities were still suitable for people 'like them' when interviewed in secondary school. These testimonies appear to show that watching certain kinds of 'grown up' science programmes on TV was considered to be fine, while science play and other hands-on activities were deemed to be inappropriate.

The incongruity of hands-on science activities for these 'grown up' WBWC students emerged again when students discussed how the continued association between 'doing science' and being 'messy', previously considered an appealing factor of out-of-school science (*see* Chapter Five), presented itself as an obstacle to participation at home:

I've never really tried experiments at home because my mum would scream at me if I... tried vinegar and bicarb ... oops.

<div align="right">(Bobster, male, year 8)</div>

I'm not allowed to do (experiments) at home… But then there was one time like I was out with my friend and then we put a mint in Coke and it exploded.

<div align="right">(Celina, female, year 8)</div>

I'd be too scared (to do experiments), I'd mess it up, like destroy the house or something.

<div align="right">(Hedgehog, male, year 8)</div>

These quotes suggest that the students considered science experiments at home as 'naughty' activities, regarded with unease. Such behaviour was 'irresponsible' and could result in damage to the home and potentially punishment from parents. This indicates a lack of encouragement from the families to 'tinker' and explore – habits which have been suggested as important in supporting interest and learning in science (Woolnough, 1994; Woolnough & Allsop, 1985), and in the development of science-related dispositions. It is also perhaps reflective of findings presented in the previous chapter that parents were enacting typical White working-class practices of leaving their children to amuse themselves. WBWC parents may actively dissuade their children from making a mess in their house during their unsupervised leisure time, which increased as students got older and when work commitments restricted parents' free time:

> I - As a family what sort of things do you do on a typical weekend, I mean if anything together?
>
> Marigold - Not a lot these days because he'd obviously rather be with his friends the age that he's at. So ... he'll either go and play football with them or ... I mean I have to work every other weekend so ... you know I don't ... when I'm at home he's normally off with his friends.
>
> (Marigold, MacTavish's mum, year 9)

> I - As a family is there anything that you guys do?
>
> Dave - No, she doesn't really hang about enough does she?
>
> Leah2 - No… we're not in her crowd… I think the only time, really, we spend together is when we're on holiday.
>
> (Dave and Leah2, Celina's parents, year 9)

> I - Do you encourage her to do anything, any kind of additional activities outside school, like you know at the weekends, any particular kind of things?
>
> Shelley - Well she socialises with her girlfriends a lot. Um, no she still hates the boundaries of be home by 10... *she is a normal 16-year-old girl as in make-up, making herself look pretty and likes to socialise at weekends*… Her girlfriends love coming around. They come over for her 16th and things like that. She's very, she's very mature for her age, but she also remembers that she's a 16-year-old child… you're not going to be judged because you want to do something silly. We… our latest game at the moment is hide and seek.
>
> (Shelly, Connie's mother, year 11, emphasis added)

Shelley had been more encouraging regarding Connie's earlier engagement in science, but later interviews indicate that she considered out-of-school science to be one of many opportunities to be playful with her children, rather than to specifically cultivate an interest in science for her children. Connie had not expressed particularly scientific dispositions in her year 6 interviews, and showed little interest in out-of-school science engagement once she reached secondary school:

> I don't know, I just think that I do enough science like in school and I don't need to do any more.

> (Connie, female, year 9)

Connie's preference for activities such as 'making herself look pretty' suggests that playing with science and watching popular science programmes on TV could have been seen as at odds with what Shelley called 'normal' 16-year-old (White British working-class) female behaviour. The subjectivity of her perspective is argued to reflect Shelley and Connie's similar performances of the hyper-feminine 'girly-girl', which is characterised by its negation of the masculine (Francis, Archer, Moote, DeWitt & Yeomans, 2016). Thus, there is an implication that receptiveness to discourses of 'science as masculine' (L. Archer, DeWitt, Osborne et al., 2013; L. Archer, Moote et al., 2016b) meant that Shelley did not deem science-related play and entertainment to be typical practices for the 'mature' White British working-class female habitus, while other forms of play – with younger family members – were still acceptable. Indeed, this latter practice would be considered a suitable behavioural constituent of the 'caring' persona many White working-class women are expected to inhabit, particularly with relation to family members (Skeggs, 1997). It is arguable that, of all the female participants in this study Connie most closely embodied traditional WBWC femininity.

'Growing out of science' was the rationale espoused by many students who had previously only reported engaging in 'science play', however it was also used by students who had reported engaging heavily in experiential science activities as well as consuming science media. One of these students, Hedgehog, claimed to have grown out of science when interviewed in year 9, although when interviewed at the same point his father, Larry, somewhat contradicted this account by describing a

science experiment involving making a volcano, which Hedgehog had recently done at home. As discussed in the Methodology Chapter, critical realism acknowledges the fallibility of responses, so instead of trying to ascertain which participant was telling the 'truth' one should focus on whether their accounts have been distorted by ideology (Wainwright, 1997). Further clues emerge when Larry later acknowledges that Hedgehog's engagement with science had diminished over the years:

> I suppose since primary school he doesn't do as much sort of experiments and messing around at home, because *obviously, you know he's got other interests* i.e. you know social media, Xbox and you know going out with his mates and you know doing more sporting activities.
>
> (Larry, Hedgehog's father, year 9, emphasis added)

Larry's observation that Hedgehog's replacement of 'messing around' with science experiments with what he apparently considered as typical adolescent leisure activities (computer gaming, socialising with friends and engaging with social media) as 'obvious' is interesting, given that they had previously reported enjoying doing science-related activities together. Larry's wording implies Hedgehog's earlier interest in science-related activities was not as a result of him having enduring science-related dispositions but of youthful play, thus the decline in Hedgehog's engagement was spoken as a *natural and expected* product of 'growing up'. Hedgehog's account at this stage appears to emulate these discourses through his dismissal of out-of-school science activities as 'childish'.

Larry's further declaration in his year 9 interview that he personally did not have science-related dispositions: "I'm not overly keen on it", marks a contrast to what was reported in his year 6 interview: "(I enjoy) doing various experiments and seeing things and seeing how they achieve things and how things work and stuff". In a similar fashion to the mothers described in Chapter Five, Larry's later interviews exhibit an apparent lack of conviction in expressing scientific dispositions. Now Hedgehog was an adolescent, Larry would not push him to engage in extra-curricular science and he appeared to be distancing himself from science engagement now it no longer played a role in family activities.

Hedgehog's later perspective of out-of-school science was like many of the students in the study. Past associations between science and play were derided by them in the

interviews as childish, although perhaps not always convincingly. It has been argued young people are under social pressures to transcend the immaturity of youth while acquiring and exhibiting the culturally appropriate feminine and masculine traits fit for adulthood (Driscoll, 2002; Hudson, 1984) . Participants' exaggerated emphasis on being 'too grown up' for science activities, even at the relatively young age of 13, suggest they were consciously trying to shed their former childish dispositions to perform a recognisable 'adult' habitus, one which they decided had little time for science outside of the school environment. Furthermore, students were not actively encouraged or pushed by their parents to maintain earlier engagement, as this was seen to be a 'natural' product of them growing up. If ongoing, out-of-school science engagement really is a significant factor in ongoing science participation, then these participants would be in the least likely position to continue post-16.

While the majority of the participants at age 13 onward appeared to adhere to the idea of out-of-school science being childish or 'generally not for them', a small minority spoke in different terms about their ongoing engagement (or eventual non-engagement) with science. These students are discussed in the next sub-section.

6.3. School science/STEM clubs

Of the few participants who did report ongoing participation in out-of-school science activities, the engagement took the form of school-based science/STEM clubs. As suggested in Chapter Two, access to such clubs is not universal, and has been found to be constrained for students from disadvantaged backgrounds. In the study, several of the students were unaware of whether their secondary school operated a science or STEM club. Of those who did report the existence of such a club, three attended and, of these three, only the two male participants reported doing so continually throughout years 8 and 9 (Bobster and Football Master), while the female participant (Danielle) left after one session. This section presents the varying experiences of five student participants when talking about their school science/STEM club, and discusses the influence of gender, class and race in these differences in making participants feel at home – or not – in that environment.

6.3.1. Science clubs are for 'special people'

For two boys in the study, the school science/STEM club allowed them to shift easily between the science classroom and out-of-school science activities while in secondary school. Admittance to these clubs, like Bobster and Football Master enjoyed, led to what they saw as privileged access to extra-curricular activities such as visits to universities, science laboratories and external speakers. Through the two boys' interactions with science clubs, science began to be constructed as for a group of 'special people', a group to which (due to their placement in the top set for science) they belonged:

> Because there's more, um, there's people there that actually know what they're talking about and they know stuff, so it's not just the teacher waiting for people to get, not, the less intelligent people to get the answers and it speeds everything up... we're able to do more now that we're older. *They trust us more*, so it's just more fun for everyone (Football Master, year 9, emphasis added)

> Um, we are the top group in our year, so *there's a lot of respect for us amongst teachers*. That's nice and I like the fact that I'm also going to science club with one of my friends from, well with a couple of my friends from Triple Science, so *we've always got like this idea of superiority* amongst the class as such. (Bobster, year 9, emphasis added)

Both Football Master and Bobster attended the same science club and both reported having a different relationship with their science teachers than their peers, due to their special status of being in the top set for science and attending the science club. They were 'respected' and 'trusted' by their teachers, allowing them autonomy to work on their own projects at their own pace:

> I like the people (at science club), which has a small impact, but I like being able to learn science away from the class. In a class, you can have everyone there and sometimes it can be a bit pressured to get on with what you want to do. But you're at your own pace ... and have fun while learning. (Bobster, male, year 8)

The special status of science resulted in these male students enthusiastically taking up the discourse of science as a preserve for the 'clever' (L. Archer, DeWitt et al., 2010), and embraced being identified as such:

Whereas when I was in primary school I was like yay, science, fun, but now it's like this is awesome… it gives you a wider understanding of everything and it, I think *it makes you more intelligent* as a person. I like science. (Bobster, male, year 9, emphasis added)

I like science. I wanted to get like more, I wanted to gain more knowledge from it… I just think science is fascinating… it helps you… Um, like your vocabulary widens from doing stuff like that… Your knowledge, you get more information and it just helps you for life. (Football Master, male, year 9)

According to his responses, it appears Football Master's prior engagement with abstract forms of scientific knowledge, as reported in the previous chapter, combined with his high-attainment in science afforded him a sense of ease within his school science/STEM club. It is argued that these forms of science-related cultural capital had *exchange-value* in his school science/STEM club, and his attendance of the club served to reproduce this capital to be used again in the science classroom. These findings imply that the early development of scientific dispositions through experiential science activities is not necessary to enable someone to feel 'at home' in science, but rather how familiar and at ease they are with canonical 'cold' scientific knowledge.

Chapter Two discussed how the consumption of 'cold' forms of knowledge has been found to be a common practice among the middle classes (Ball & Vincent, 1998) and how the link between science and 'braininess' which excludes many young people (L. Archer, DeWitt & Willis, 2013) can, conversely, make the formal science field particularly attractive for middle-class males. Indeed, throughout the year 8 and year 9 interviews, both Football Master and Bobster began to exhibit dispositions which appeared to align with the notion of 'middle-class masculine intellect'. This form of masculinity equates academic success as being a result of *natural*, cerebral intelligence and is distinguished from the 'feminised' form of academic success associated with diligence and hard work (Ingram & Waller, 2014). It has also been argued to be linked to feelings of entitlement for the most valuable forms of cultural capital (Ingram & Waller, 2014), such as that accessed through the school science/STEM club, as well as expressions of confidence and arrogance (L. Archer,

Dawson, Seakins, DeWitt et al., 2016), as demonstrated by their reported feelings of 'superiority'.

While Football Master and Bobster appeared to embrace the typically White middle-class masculine dispositions mentioned above, this paralleled an increasing rejection of traditional, physical forms of masculinity associated with the working-class, which was particularly noticeable when they talked about their engagement with football:

> Bobster - I had to play football - oh God. Um, yeah, I've always sort of hung around with the outsiders as it were.
>
> I - What makes someone an outsider?
>
> Bobster - Not liking football, and being all 'grr', yeah.
>
> I - Grr? Masculine?
>
> Bobster - Grr, yeah, like that's a scientific term.
>
> (Bobster, male, year 11)

Bobster and his friends were 'outsiders' amongst their peers who appeared to perform a hegemonic version of working-class masculinity focussed on physical strength and prowess (Ingram & Waller, 2014). Football was considered to be interconnected with this form of masculinity which Bobster scorned 'I had to play football – oh God'. Even Football Master, whose own pseudonym shows at least a prior interest in football, did not mention football at all in his later interviews. When interviewed in year 13 his response to a reminder of his pseudonym was "well that's a lie" and he confirmed he no longer played football as a hobby.

Football Master and Bobster's interview responses appear to echo a discourse found in previous studies, which suggest that one cannot be clever and be working-class (Ingram, 2011). Bobster and Football Master's apparent dismissal of physical forms of White working-class masculinity and their active acceptance of the middle-class, masculine, 'clever' identity, comfortably performed in their STEM Club, suggests that for these young men being working-class and being successful in science do not mix.

Football Master and Bobster's accounts contrast significantly with their fellow male participants, Dave and MacTavish, who had previously been very positive about science and engaged in experiential science activities in their spare time. Now,

however, Dave and MacTavish rejected engagement in their school's science/STEM club *in favour of* football:

> Um ... I think they do (have a science club here)… No, (I'm not interested in going) I normally play football.
>
> <div align="right">(Dave, male, year 9)</div>

> I think there's (a science club) at lunch but I'm playing football then, it's like I love football and then if there's things like after-school, depending on what it is, I don't normally do it because, you know, *it's my time*… I've got to do things like homework and I've got just stuff to do really.
>
> <div align="right">(MacTavish, male, year 9, emphasis added)</div>

Thus, despite stating that he would have continued with his home school science kits given the right equipment only a year earlier, MacTavish emphasises prioritising football and his own leisure time over the opportunity to participate in science in the school environment. When faced with the same (arguably false) dichotomous choice as Football Master and Bobster, both MacTavish and Dave appeared to choose inhabiting traditional White working-class masculinity. This suggests that male White British working-class students in the study could not negotiate performing multiple forms of masculinity, having to choose either the expression of natural intelligence or physical prowess; a finding also found in Ingram's (2014) study of classed masculinity. Indeed, it is arguable that of all of the male participants in the interviews, MacTavish most closely embodied traditional male White working-class dispositions due to his preference for physical activity and strong assertions of independence. Thus, MacTavish became one of the participants who was 'too grown up' for science (*see above*).

It could be argued that Bobster's and Football Master's engagement in science activities provided by their school science/STEM club allowed them to engage more easily in science in school due to the similarity of fields, particularly between the science club and the top set of science they occupied. In their school science environment (field) these male participants were at this time, as Bourdieu described it, like 'fish in water' (Bourdieu & Wacquant, 1992; Gokpinar & Reiss, 2016). Subsequently, continued participation in science would likely be considered more of a natural step for them than the other participants.

6.3.2. Science clubs are 'for boys'

Unlike Football Master and Bobster, the school science/STEM club did not provide the same appealing environment to the two female participants who also expressed an interest in out-of-school science engagement in later interviews. This sub-section explores the experiences of one of them, Danielle, who had previously talked extensively about her interest in science, including her early science aspirations and her engagement in both 'cold' and experiential forms of out-of-school science activities (*see* Chapter Five). Of the twelve WBWC student participants in this study, Danielle was the only participant who had attended a science club session prior to secondary school, however her experience was short-lived as reported by her mother, Sandra:

> I said why can't you do science? She said well, oh no *it's a boy thing*. And I said it's not. They had Mad Science they've called it at school. It's an after-school club on Monday and she said *I'm not going because it's all boys*. You can see what I mean when you're fighting against it aren't you? I said well you should at least go along and see if you enjoy it. It's all these experiments and she said oh, it's fun, we did all this… And then she stopped going because it was all boys and she had no girls to talk to.
>
> <div align="right">(Sandra, Danielle's mother, year 6, emphasis added)</div>

Danielle's experience of 'belonging' in a science club was quite different from that of Bobster when he attended, though they shared similar histories of engagement in science outside of school. While Bobster spoke of the collegial relationships he shared with friends who attended the club with him, Danielle 'had no girls to talk to' and felt it was 'a boy thing'. Despite strong encouragement from her mother, and admitting to enjoying the activities, it appears Danielle stopped attending.

Science club was not mentioned by Danielle in her year 8 interview, and in year 9 she stated she wasn't aware of the existence of one in her school. Nevertheless, when in year 11 she reported having been to the club at secondary school once, although it wasn't clear at what point this had been. The experience was, again, not favourable:

> I went (to science club) once. It was boring. You just set paper on fire and watched how it burned, but it doesn't burn the paper. It just burns the fumes. It was rubbish. *It's not the kind of science I like. I don't like visual*

science. I'm a bit of a boff. I'd rather sit and read an article on Biology and write about like I don't know…

(Danielle, female, year 11, emphasis added)

Like her male peers discussed above, Danielle's comment suggests her own subscription to an intellectual disposition: 'I'm a bit of a boff'. However, unlike Football Master and Bobster the club did not appear to provide the same opportunities to indulge in these intellectual dispositions. She criticises the demonstration of 'visual science' as 'not the kind of science she likes', instead preferring the theoretical 'cold' knowledge she could consume in her own time. This is the reason Danielle gives for no longer attending the science club. However, interviews with her mother suggest other factors were also involved:

When she was at (Midlands Primary School) she used to do every after-school club, but at (Malcolm High School) she's not keen at all. She didn't do the drama group, she didn't do any of it.

(Sandra, Danielle's mother, year 9)

In attempting to understand the different explanations offered by Danielle and her mother, one must once again consider what underlying mechanisms may be involved. A later interview with her mother provides further clues:

This is the trouble with (Danielle) – a lot of it is friendship, she does what her friends are doing.

(Sandra, Danielle's mother, year 11)

Sandra's explanation of Danielle's friendships being connected to her self-exclusion from school clubs is reflective of what Solomon (1997) calls 'social solidarity'; her friends did not attend a science/STEM club and this potentially exacerbated her feeling of not belonging there. As discussed in Chapter Two, working-class females are particularly susceptible to stereotyping in adolescence (Croxford, 2006). It is therefore possible that Danielle's earlier engagement in science diminished in secondary school due to her increasing alignment with dispositions associated with White British working-class females. For example, as discussed elsewhere by the ASPIRES project, Danielle's physical appearance appears to adhere to a hyper-feminine style, with meticulous – but heavy – make-up and hair extensions worn both in and out of school (L. Archer, Moote et al., 2016a). Nevertheless, her interviews indicate Danielle experiences a tension between her outward alignment with WBWC

femininity and her inward construction of cerebral intelligence, evidenced by her construction of herself as a 'boff' – a term which connotes cleverness but also someone who is physically unattractive (L. Archer, DeWitt et al., 2010).

We are unable to *know* whether or not Danielle's science club had enough activities related to cold forms of scientific knowledge. What is hypothesised is that her account of self-exclusion was distorted by a struggle to reconcile her emerging adolescent dispositions, aligned closely with many aspects of WBWC femininity, and dispositions that would position her as an intelligent person who *belongs* in the school science club. Danielle's experience of primary school science clubs had revealed to her a dominant construction of science as 'a boy thing', and the discourse of science as for males would become even more prominent in secondary school (L. Archer, DeWitt et al., 2010). It is argued that the juxtaposition between Danielle's physical WBWC hyper-femininity and the middle-class, cerebral masculinity dominant in science reveals a habitus in conflict, one which Danielle appears to have (uneasily) resolved by abstaining from future attendance in an out-of-school science activity she may have otherwise enjoyed. It also points to an uncertain future for Danielle's ongoing science participation within formal education.

6.3.3. 'It's too late for me to go to the school science/STEM club'

While Celina had not previously expressed the same level of intrinsic interest in science as Danielle, she had shown some interest through her earlier engagement in the consumption of science media. The positive influence of a teacher meant Celina reported in year 11 that her general interest in science had increased: "wow this is like amazing". She attributed this increase of interest to her improvement of understanding science:

> In year 9 I didn't really understand (science), but now I do, like most of it. So, I get like really happy when I realise that I can link back to things like… like I actually understand it. Cos I never used to understand anything, I don't know why … I guess I was like absent-minded I guess.
>
> (Celina, female, year 11)

It appears school-level factors informed Celina's confidence levels with science, motivating her to attempt to engage with science in her free time, in distinct contrast

to the rest of her peers. Unfortunately, it was now too late for her to engage with her school science/STEM club and there were no alternatives available:

> I - Do you do any kind of science or sciencey activities outside of school?
>
> Celina - Um … well I'm trying to, but there's not a lot like around me that I can find… I'd like to try and do experiments like with other people who are fascinated… There's no (science club) available for year 11, it's just like study support and everything, it's just generally for 7 and 8s now.
>
> <div align="right">(Celina, female, year 11)</div>

When her interest emerges Celina's lack of access to a school science/STEM club appears, at first hand, to be a matter of bad luck. However, this issue of poor timing does invite a further exploration of why she did not attend when she was in the appropriate age group. Celina was considered a high-achiever in her school (as will be discussed further in the next chapter), which according to Football Master and Bobster should make her belong in her school science/STEM club. Nevertheless, one conjectures whether her earlier lack of self-confidence in science is a result of Celina's construction of herself as a 'good student' who achieves academic success through diligence and hard work i.e. the successful female student, rather than one who is naturally and effortlessly clever i.e. the successful male student (L. Archer, DeWitt et al., 2010; Ingram & Waller, 2014). Hence her lack of understanding in science is presented as due to her being 'absent-minded'. While Celina shares Football Master's early familiarity with cold forms of scientific knowledge, it does not appear to have manifested in the same confidence and entitlement he expresses about belonging in his school science/STEM club (*see above*). In consideration of Danielle's experience of science clubs being 'a boy thing' it is possible that Celina equally found that her school science/STEM club was not suitable for her. As science continues to be constructed as a 'hard' subject at A Levels, it appears that, much like Danielle, Celina's future science participation is in doubt.

6.4. Keeping school and school-like activities out of leisure time

A third female participant presents somewhat of an unusual case for this study, in that her interviews paint a puzzle regarding her motivations behind self-excluding from her school science/STEM club. LemonOnion was the only participant who

claimed to never engage in out-of-school science, aside from reporting occasionally watching popular science-related TV programme (e.g. Brainiac in her first interview, NCIS in her year 11 interview). As such, LemonOnion did not report engaging in her school science/STEM club:

> I - what about sciencey activities outside school?
> LemonOnion - Don't do any of them. I don't think there is any ... there used to be a science club, but nobody went to it, so that it got cancelled.
>
> (LemonOnion, female, year 11)

LemonOnion's consistent lack of engagement in out-of-school science suggests she does not consider herself to have 'grown out' of such activities, like many of her peers, but was rather never interested in the first place. Furthermore, her apparent disinterest in dedicating extra time to spend engaging in science implies her self-exclusion from her school science/STEM club was likely not for the same reasons as Danielle and Celina. Instead, in order to theorise an explanation for LemonOnion's position on science engagement it serves to look at what out-of-school activities she *has* engaged in. LemonOnion engaged in sports, like many of her peers, and other activities such as drawing, writing and dancing (which was particularly common amongst the other girls of the study). However, LemonOnion's main – and most consistent – hobby was attending a local Royal Marines Cadet Corps, which allowed her to be active outside:

> LemonOnion - Well I like going commando… like climbing trees and running 'round and stuff.
> I - Mm. Doing stuff outdoors?
> LemonOnion - Yeah... Well it's really fun really because you get to just like get dirty and things. Like at Cadets you get as dirty as you want, they just don't care… You just get to fire rounds and things, it's fun.
>
> (LemonOnion, female, year 6)

In particular, LemonOnion enjoyed the practical, hands-on activities and expressed no interest in developing academic skills:

> I'm not so into the lectures. I like map reading cos it's something to do, but … and cooking in the field, that's quite funny to actually get to cook… but *I do the gymnastic team to get out of lectures*.
>
> (LemonOnion, female, year 6, emphasis added)

This theme continued in later interviews:

> I - What do you like about Cadets?
>
> LemonOnion - Um, well a lot of people say who have already been there that *it's like boring, because you just sit there and you learn about things*, but I usually go there to like see my friends, just a bit of something to do, and like *obviously when you go out on an exercise it's quite fun*, run round, see people, pretend.
>
> (LemonOnion, female, year 9, emphasis added)

LemonOnion's aversion to academic activities is interesting, given her strong record of educational attainment in school (as will be explored further in the next chapter). A school science/STEM club could have provided an opportunity for LemonOnion to engage in hands-on, practical activities; however, her interviews indicate she did not consider attending it at any point. An argument that perhaps LemonOnion simply did not enjoy science does not stand up very well, as in her interviews she mentions generally liking science in the school context:

> Science is quite fun… in school.
>
> (LemonOnion, female, year 6)

> I like doing practical work, but I don't mind book work, it just depends what type of book work it is cos science is okay, I didn't used to like it, but I like it better this year.
>
> (LemonOnion, female, year 8)

> I've got a bit more like focussed in science *and* liking it a bit more - I've got better *because* I like it more.
>
> (LemonOnion, female, year 11, emphasis in original)

It is possible that the heavy time-commitment of cadets, which LemonOnion referred to in several of her interviews, meant that LemonOnion – like MacTavish above – wanted to keep the rest of her leisure time as her 'own time'. With this and the above points in mind, it is suggested that LemonOnion's apparent disregard of the learning opportunities afforded by her cadet experiences conveys her desire to keep the realms of school and the outside world separate.

A further detail emerges in LemonOnion's year 9 interview, when asked if there was anything she enjoyed about science in school:

> I like doing things like when you have to go to make posters and stuff, like get in groups, and *you get to do your own learning*. I didn't mind doing the whole gene stuff, learning about genes and how all that works, but everything else it just didn't really make sense like. Well it made sense, but not the fact that we had to learn it, it's like why do we have to be learning this? *It's not something we're going to really need*, unless you wanted to be a scientist.
>
> (LemonOnion, female, year 9, emphasis added)

LemonOnion's questioning of the narrow focus of the science she was being taught is reminiscent of wider criticisms of the STEM pipeline focus of school science education (*see* Chapter Two). In particular, her statements of wanting to 'do her *own* learning' on things '*she* would really need' reflects her placing an importance on knowledge and expertise with *use-value*, derived from first-hand, personal experience. As discussed in the previous chapter, these have been argued to be typically White working-class dispositions, although LemonOnion's accounts are less explicitly gendered than Danielle's or Celina's, in that in the statements presented above she does not appear to consider the difficulty of science to be an issue, only the value of it. Indeed, LemonOnion has previously claimed to be unlike other girls, and rejected the idea of being 'girly':

> They're like girly girls and I'm just like 'Let's get out there and do it'.
>
> (LemonOnion, female, year 6)

In this context, it is argued that LemonOnion's self-exclusion from her school science/STEM club was not based on it being 'for boys', or because she didn't see herself as being 'clever enough', but due to her classed and racialised position on the lack of use-value scientific knowledge represented. LemonOnion may have considered her school science/STEM club to be too much like school science to be worth attending. If out-of-school science engagement is to be considered as a significant influence on ongoing science participation, we would expect LemonOnion to be amongst those who were not considering carrying on studying science post-16. Indeed, as we will see in section 6.4. below, this was not the case at all.

The interview cases have revealed a complex picture regarding participants later out-of-school science engagement. Most participants reported no longer engaging in out-of-school science activities once they reached secondary school, while a small

minority reported regularly attending their school science/STEM club when it was available to their age range. Before the relationship between this and ongoing science participation is explored, however, the chapter takes a look at the data offered by the ASPIRES2 surveys to see whether these patterns emerged in the wider cohorts and if there are noticeable differences with students from other sociocultural backgrounds.

6.5. Findings from the year 8, 9 and 11 ASPIRES surveys

The ASPIRES project conducted three further online surveys from when the study participants were in year 8, 9, and 11. Table 6.1 gives details of the respondents for these surveys, showing that the WBWC respondents made up a similar proportion of the total population at each point, and the gender split of the WBWC respondents was fairly even.

Table 6.1: Respondent profiles from ASPIRES surveys, years 8, 9 and 11

Survey	Total Number of Respondents	WBWC Respondents	Female WBWC Respondents	Male WBWC Respondents
Year 8	5634	519	296	220
Year 9	4600	497	226	171
Year 11	13421	1096	575	521

This section explores the responses related to student engagement in the out-of-school science activities discussed in the previous chapter as well as responses to a new question added to the later surveys regarding student attendance of their school science/STEM club, in order to contextualise the findings from the interviews.

6.5.1. Student cohort survey – later engagement in out-of-school science activities

As with the year 6 survey, respondents were asked how regularly they did the following science-related activities in their own time: *Do science activities (e.g. science kits, nature walks, do experiments)*; *Read a book or magazine about science*; *Visit web sites about science*; *Visit a science centre, science museum or zoo*; *Watch a*

TV programme about science or nature. For each activity type respondents were requested to report the regularity of their engagement according to the following criteria: *At least once a week; At least once a month; At least once a term; At least once a year*; *Never.*

This sub-section explores wider patterns of WBWC engagement found in the survey responses of students in secondary school. The same limitations as discussed in Chapter Five remain, but it is also worth noting that the surveys drawn upon do not represent longitudinal data with tracked students, which constrains the inferences made about changes over time. However, the survey data still serves to present a description of how WBWC students generally tend to report their science engagement at different points in their school careers, thereby contextualising the findings from the interview study. Of particular interest was whether the complete drop in engagement found in many of the interviews was also observable in the wider student cohorts, and whether there were any noticeable trends when comparing the responses by gender (F/M), race (WB/ME) or class (WC/MC).

Tables 6.2., 6.3. and 6.4. below report percentages of students who reported regular engagement in science activities (those who responded *at least once a week*) and percentages of respondents who reported minimal engagement in these activities (those who responded *never* to all of the activity items listed). The three tables report these findings from the student cohort surveys for years 8, 9 and 11 respectively and are discussed together after the data are presented.

Table 6.2: Percentages of year 8 students reporting regular engagement in out-of-school science

Activity type		Sociocultural group							
		WBWC		WBMC		MEWC		MEMC	
		F	M	F	M	F	M	F	M
Consuming science media	Read a book or magazine about science	4.7	9.6	4.9	6.4	7.6	16.7	14.0	21.1
	Visit web sites about science	3.7	7.3	5.4	5.8	17.9	18.9	16.1	18.5
	Watch a TV programme about science or nature	20.0	22.8	19.6	30.5	20.7	37.8	23.6	38.1
Experiential science activities	Do science activities e.g. kits, nature walks, experiments	9.5	13.2	10.4	12.4	13.8	21.1	14.0	20.2
	Visit a science centre, science museum or zoo	1.7	1.8	0.6	0.5	1.4	1.1	0.9	2.4
Never engaging in any of the above activities		70.9	71.4	63.1	64.1	68.3	64.4	59.2	51.2

Table 6.3: Percentages of year 9 students reporting regular engagement in out-of-school science

Activity type		Sociocultural group							
		WBWC		WBMC		MEWC		MEMC	
		F	M	F	M	F	M	F	M
Consuming science media	Read a book or magazine about science	3.1	6.4	3.5	6.7	18.7	16.3	10.2	21.9
	Visit web sites about science	6.2	5.9	6.3	9.2	16.4	26.9	17.2	23.4
	Watch a TV programme about science or nature	14.7	19.3	13.8	26.5	18.7	26.9	22.7	35.4
Experiential science activities	Do science activities e.g. kits, nature walks, experiments	8.0	9.4	5.7	8.7	9.0	12.5	11.4	10.2
	Visit a science centre, science museum or zoo	0.4	1.2	0.6	0.5	1.5	1.9	2.7	2.6
Never engaging in any of the above activities		77.9	80.1	68.9	62.8	64.9	61.5	61.6	51.1

Table 6.4: Percentages of year 11 students reporting regular engagement in out-of-school science

Activity type		Sociocultural group							
		WBWC		WBMC		MEWC		MEMC	
		F	M	F	M	F	M	F	M
Consuming science media	Read a book or magazine about science	4.2	5.4	4.8	7.8	9.1	14.8	14.8	13.6
	Visit web sites about science	9.4	16.3	15.1	23.5	24.5	26.3	28.3	35.1
	Watch a TV programme about science or nature	10.6	16.7	11.5	20.8	14.4	28.3	17.0	26.6
Experiential science activities	Do science activities e.g. kits, nature walks, experiments	5.6	4.6	5.0	6.8	8.4	10.8	8.2	10.8
	Visit a science centre, science museum or zoo	0.2	0.4	0.3	0.5	2.2	1.5	1.1	1.7
Never engaging in any of the above activities		80.3	76.4	71.9	66.0	75.5	72.2	60.7	62.1

As anticipated, Table 6.2. shows a trend of an overall drop in regular engagement for all science activities in the year 8 survey compared to the data reported on the year 6 survey in Chapter Five. Tables 6.3. and 6.4. show this trend continues for most of the activities listed in the year 9 and year 11 surveys with the exception of the activity *read a book or magazine about science,* which varies somewhat depending on the sociocultural group and *visit web sites about science* which shows a trend of overall increased reported engagement between years 8, 9 and 11 – to the extent that the year 11 percentages exceed those from year 6 (*see* Chapter Five, sub-section 5.3.). It is possible that this trend is due to the increased use of web-sites for GCSE revision, something noted in wider educational literature (Valentine et al., 2005). As in the year 6 survey, there is a trend of male respondents tending to report higher levels of regular engagement for all activities and a trend for Minority Ethnic respondents to report higher levels of regular engagement for all activities.

In a pattern echoing the interview findings, the trend observed in year 6 of WBWC students appearing to prefer practical, hands-on science activities on a regular basis over 'cold' forms of science engagement becomes less noticeable in the latter three cohort surveys, culminating in more similar responses in year 11. In general, working-class respondents reported similar percentages of regular engagement to their

middle-class peers, with the exception of trends for WBMC boys to be more likely than their White British peers to report regular engagement in science websites and TV programmes in year 9 and year 11, MEMC boys were more likely to report regular engagement in science websites than their Minority Ethnic peers in year 11. In other words, as with the year 6 survey responses, class again does not appear to be a factor for WBWC students reporting *regular* engagement with out-of-school science.

Similar classed and racialised patterns of *minimal* out-of-school science engagement described in year 6 (*see* Chapter Five) also appear for WBWC students in the later surveys, with a trend of WBWC students reporting the highest percentages of minimal engagement in out-of-school science activities at each point. Notably, however, their percentages are now closer in size to the MEWC female respondents in the year 8 and year 11 surveys. The MEMC males still represent the group least likely to report minimal engagement and their percentages remain much more consistent than the other groups, who have a more noticeable increase of respondents reporting minimal out-of-school science engagement each year the surveys take place.

The findings from these surveys parallel those from the interviews discussed in this chapter, showing an overall tendency for students to engage less in out-of-school science activities as they enter adolescence. The consistent trend of higher response rates of minimal out-of-school science engagement for WBWC students points to a mechanism that is strongly classed, with some gender and race effects. Indeed, in year 11 over three-quarters of WBWC respondents reported minimal out-of-school science engagement compared to less than two-thirds of MEMC students. Using the findings from the interviews, it is hypothesised that this can be explained by the increasing autonomy WBWC students have over their own time as they grow older. This is compared to students from middle-class and certain Minority Ethnic backgrounds whose parents are still actively involved in planning their child's leisure time into adolescence – particularly with regard to activities and practices which would facilitate their educational success (Francis & Archer, 2010; Lareau, 2011).

6.5.2. Student cohort survey – attendance of school science/STEM clubs

A new question was added to the year 8 survey, which asked students *Is there a science or STEM club at your school? If so, do you attend it?* Students had the option to respond 'yes' or 'no' to both questions, with the additional option of 'not sure' for the first question. As the school science/STEM club was the main opportunity for the interview participants to continue engaging in out-of-school science activities while in secondary school, this survey data provided an opportunity to observe whether similar patterns of attendance could be found across a wider student cohort. In particular, I was interested in discerning whether the gendered patterns of club attendance found in the interviews was also observable in the wider student cohorts, and whether there were any noticeable differences between WBWC respondents and those from other social class and/or ethnic backgrounds.

Table 6.5. presents the percentages of respondents who reported in the affirmative that there was a science/STEM club in their school, while Table 6.6. presents the percentages of those who responded there was a club and that they attended it. The tables do not include the year 11 responses, as the interview data suggest 'science clubs' at this age tended to be for GCSE revision rather than hands-on activities such as Football Master and Bobster reported in years 8 and 9 (*see* sub-section 6.3.). As discussed previously, there are limitations to the use of quantitative data. For these particular data it is noted that Table 6.5. does not reflect the nuances of whether respondents from certain backgrounds are more likely to *have* a school science/STEM club in their school or if they are perhaps more *aware* of one existing. Nevertheless, as before the survey data provide useful descriptions of wider patterns to contextualise and support the findings from the interview data.

Table 6.5: Percentages of students reporting a science/STEM club at their school

Survey	Sociocultural group							
	WBWC		WBMC		MEWC		MEMC	
	F	*M*	*F*	*M*	*F*	*M*	*F*	*M*
Year 8	38.9	43.0	47.5	48.7	52.1	41.6	53.0	42.6
Year 9	32.4	43.2	44.3	46.5	40.3	38.2	49.0	37.7

Table 6.6: Percentages of students reporting school science/STEM club attendance

Survey	Sociocultural group							
	WBWC		WBMC		MEWC		MEMC	
	F	*M*	*F*	*M*	*F*	*M*	*F*	*M*
Year 8	6.1	7.6	9.5	10.1	10.8	21.6	12.6	15.2
Year 9	1.4	5.5	5.8	6.8	7.5	7.7	9.4	11.0

Table 6.5. shows a mixed picture regarding students' responses to the existence of a school science/STEM club. Class, gender and ethnicity are observed to interact in different ways and to varying extents for different social groups, but what is of particular interest is that while WBWC students tended to be the sociocultural group least likely to report a school science/STEM club in their school (compared to students from other social class and/or ethnic backgrounds), it is the WBWC female respondents who are noticeably the least likely overall. Table 6.6. shows this trend repeating for those who responded that they attended their school science/STEM club, with WBWC females again located at the intersection of gendered, classed and racialised differences in STEM/science club attendance. These findings suggest that Danielle (from the interview study) was not alone in feeling that the school science club was 'not for girls like her'.

As indicated previously, the classed and racialised differences in awareness *and* attendance of school science/STEM clubs as found in the survey data could be explained by WBWC students being less likely to be located in a school which runs such clubs. The findings could also imply that WBWC students are less likely to be aware of such clubs within their schools even when they are available. Differential access to enrichment activities is a cause of concern in itself, however the presence of similar patterns in those reporting attending such clubs when they are known to exist suggests that the underlying mechanism generating these patterns is not limited to access. The differences of gender for WBWC students serves to support this hypothesis.

When combined with the findings from the interview data, these patterns suggest that the underlying mechanism which generates them reflects gendered, classed and racialised structures or practices. These could be the increased likelihood of middle-class and (certain) Minority Ethnic parents pushing their children to engage in activities seen as a 'good investment' opportunity, due to their association with educational achievement and the elite status associated with science qualifications and careers (Adamuti Trache & Andres, 2008; L. Archer, DeWitt et al., 2012b; Bourdieu & Passeron, 1979). The additional gender dimension indicates that the privileged position argued to be held by (middle-class) males within school science (Carlone, Webb et al., 2015) is also observable in *school-like* science fields, such as science/STEM clubs, and that White British working-class girls, by contrast, occupy the least privileged position in school-like science fields.

6.5.3. Student cohort survey – intentions to study science A Levels

The year 11 survey data also gave an opportunity to look at wider patterns regarding WBWC students' post-16 science participation. This carries with it the limitation of representing intentions to study, rather than actual uptake, however the point of time the data were collected was relatively close to the point when respondents were going to make the decision to continue, or not, with science and thus was still seen as a reasonable approximation of the percentages of WBWC who would take science A Levels. Table 6.7. presents the percentages of students who responded in the year 11 survey that they intended to study any one of the three main science A Level subjects: Biology, Chemistry and Physics.

Table 6.7: Percentages of students reporting intentions to study a science subject at A Level

A Level	Sociocultural group							
	WBWC		WBMC		MEWC		MEMC	
	F	*M*	*F*	*M*	*F*	*M*	*F*	*M*
Biology	33.9	21.0	39.1	28.1	56.9	43.3	51.5	36.8
Chemistry	19.8	20.0	25.0	27.0	45.6	39.4	46.9	39.7
Physics	7.2	23.8	13.1	35.5	14.9	38.6	20.0	42.6

As can be seen from the data in Table 6.7., WBWC students are the least likely of the four sociocultural groups to report an intention to continue with Biology and Chemistry at A Level. In Physics, however, the gender gap is so marked that WBWC males reported higher percentages of intentions to study the subject than females from other sociocultural backgrounds, resonating with wider concerns regarding the under-representation of women in physics (L. Archer, Moote et al., 2016a; Francis, Archer, Moote, DeWitt, MacLeod et al., 2016; Murphy & Whitelegg, 2006). Overall, the data suggest a tendency for WBWC students not to choose science subjects at A Levels and paints a particularly bleak outlook for WBWC girls in physics.

The theories emerging from analyses of the interview and survey data form an important thread in the overarching exploration of the second research question, which is concerned with the relationship between out-of-school science engagement and ongoing science participation for WBWC students. The next section discusses this in further detail, including considering the findings from Chapter Five to explore the potential relevance of *long-term* science engagement on WBWC participants' decisions when in year 11 of whether to continue studying science at A Levels.

6.6. Exploring relationships between long-term engagement in out-of-school science and ongoing science participation

Chapter Five discussed the relationship between WBWC students' early out-of-school science engagement and their intentions towards ongoing science participation, arguing that students engaged in both experiential science activities and the consumption of science media were likely to develop both scientific dispositions and accumulate dominant science-related cultural capital and were therefore in the strongest position to continue with post-16 science. Nevertheless, the majority of WBWC respondents from the interview study were non-committal about continuing with science when asked about their intentions – even many of those who did engage actively in out-of-school science and spoke positively about such experiences. It was suggested that the relatively hands-off approach of WBWC parents observed in the interviews could also mean that they were less likely to intervene in their child's

school choices, with the implication that students' intentions towards ongoing science participation were less related to the types of science activities they did in their spare time and more about how involved their parents were in guiding them *towards* science both in and out of school.

The availability of multiple later interviews with the same participants affords the opportunity to hypothesise the nature of the relationship between WBWC students' *early* engagement in out-of-school science and *actual decisions* regarding ongoing science participation in year 11 as well as a wider discussion of the relationship between *ongoing* out-of-school science engagement and *decisions* towards ongoing science participation. This section will explore these relationships in detail in order to respond to the second research question: *What, if any, is the relationship between out-of-school science engagement and WBWC students' participation in science A Levels?*

When asked in their year 11 interviews, nine of the twelve student participants stated that they did not plan to continue studying science post-16. Of these, only one discussed the influence of (dis)engagement in out-of-school science activities in this decision:

> Dave - I used to like enjoy doing (science), but it's like slowly died down over the years... I'm not sure why, but it may be because we don't do none of that stuff no more. (My neighbour is) like busy doing... Yeah, he's actually doing all that stuff at school... he never really used to come home and do it again.
>
> I - Um, so you don't think it's likely that you're going to choose science as an A level.
>
> Dave - No.
>
> (Dave, male, year 11)

As discussed in the previous chapter, Dave's engagement in out-of-school science was precarious because it was contingent on his ongoing friendship with his neighbour; which, as can be seen from the above quote, diminished throughout secondary school. With no encouragement coming from other sources, Dave's out-of-school science engagement largely disappeared, and this appeared to also strongly affect his intentions towards ongoing science participation. As reported in Chapter

Five, Dave had been one of the few students who expressed early intentions towards taking science beyond GCSEs, thus it is suggested that external forces played an important part in Dave's motivation to engage in science both in and out-of-school.

The explanations of the remaining eight suggested school-related factors were involved:

> I don't think anything has put me off studying science, but more there's things that I'd rather study over it.
>
> (MacTavish, male, year 11)

> I think … I want to pursue science as well, but I kind of don't at the same time. I'm scared of like failing I guess, cos I don't think I have enough knowledge to go on to do it in A Level.
>
> (Celina, female, year 11)

> Um, yeah, I'm not planning to take (science) at A Level… I just think it would be a bit too much for me at A Level. I think it's mainly just the difficulty, to be honest. I have a feeling there would be some very interesting parts to it, but I think I would focus too much on the coursework side of things.
>
> (Lucy, female, year 11)

> Um, I don't think I would (consider choosing science A Levels) … obviously like some people they obviously they like science. That's what you want to do, but I don't think … I don't *not* like it though, but I wouldn't choose it as one of my favourite subjects.
>
> (Connie, female, year 11)

> Millie - I did want to take Biology as an A level alongside my course, because I think they kind of go hand in hand. They'd help each other, but I didn't… I kind of can't really remember why I don't want to do it anymore… Um, maybe (people would take science) if the curriculum was kind of changed through like the GCSE years and… if things were put into context in real life through science then they could see how it's more applicable to the, their daily life and how they could actually use it.
>
> I - Okay, and that's one of the things that puts you off.
>
> Millie - Yeah.
>
> (Millie, female, year 11)

> I - is there anything that encourages you to continue with science after GCSE?
>
> Hedgehog - Um … probably if I wanted to be like a pilot or something… If they was to provide more like subjects at college. Cos at the minute the only

real ones they do is Biology, Chemistry and Physics. Which… if that's what you've been doing your whole life some people might find that boring. But like if they had, say… aviation wise and that, like the Physics … then yeah I would have chose to do it.

(Hedgehog, male, year 11)

I don't know really. I think it's just sort of the first like years 7, 8 and 9 the more like fun you have and them lessons, the more likely you are to go and do Triple Science. Like when we had a really dodgy teacher for year 8 and 9 it sort of put everyone's… Teachers are important… if you don't like the teacher then you're not going to try hard in the subject. Whereas if you like the teacher then it puts a good positive effect like atmosphere in the classroom, so then you do if that makes sense.

(Charlie, female, year 11)

I - Would (changing to Double Science) affect your attitude about doing science beyond A level? Were you thinking of doing it before?

Bobster - Not really no… It just affected my attitude towards the teacher.

(Bobster, male, year 11)

These students do not share a similar history of early science engagement – some only reported engaging in science play, as was the case with Connie, while others engaged in both consuming science media and experiential science activities, such as Hedgehog. When students reached secondary school their out-of-school engagement in science largely disappeared, even for Bobster who regularly attended his school science/STEM club until it ceased to exist: "that crumbled terribly", due to staffing issues. Given the minimal out-of-school science engagement of most participants at this stage, it is unsurprising that in-school factors were presented as playing a strong role in informing their decisions to continue with science at A Level.

Three participants expressed in their year 11 interviews that they *did* intend to continue with science at A Level:

I'm going to go to college and do Biology, Chemistry, Maths and History… and then a degree in medicine.

(Football Master, male, year 11)

(I'm taking) Human Biology – that's just a smart subject, it shows you tried.

(LemonOnion, female, year 11)

I was going to take Physics (A Level), but I've got to wait and get my results from my exams back, because if I don't get a B I can't do physics... I love physics... if you were sitting a physics exam... you can read the question and... do the equations and work it out, even if you knew nothing about what it was all about. That's what I like about physics. It's kind of like common sense.

(Danielle, female, year 11)

As with the participants who were not continuing with science at A Level, these three students had reported very different experiences with out-of-school science activities. Football Master had only reported engaging in consuming science media in year 6, while Danielle's account showed that she engaged in both consuming science media and experiential science activities. LemonOnion, on the other hand, reported minimal early out-of-school science engagement. In secondary school, Football Master regularly attended his school science/STEM club, when it was available, while both of the other students self-excluded.

Based on these findings, it would be tempting to state that engagement in out-of-school science activities, even those closely associated with dominant science-related cultural capital, has little association with WBWC students' ongoing science participation. However, a critical realist approach still uses these data as part of a broader picture, in order to extrapolate what mechanism may generate these patterns of participation in science for WBWC students.

The data from this chapter have shown that as students grew older their parents' involvement in their child's leisure time diminished considerably, even amongst those who had previously been active in organising or encouraging their children to engage in science activities at home. The interview data do not suggest this was the result of apathy, as WBWC parents have been accused of before (*see* Chapter One), but a continuation of what Lareau (2011) considered to be a classed parental approach of the 'accomplishment of natural growth', where working-class parents left their children to manage their own leisure time and the children's home spheres were kept distinct from the adults' – unlike middle-class families whose worlds were much more integrated. The classed differences in how parents involved themselves in their children's decisions about the future will be explored more in the next

chapter, which is focussed on students' experiences in school. However, it is argued that this approach to upbringing had a profound effect on whether the students of this study saw science engagement, either in-school or out-of-school, as suitable for someone 'like them' as they grew older.

While the WBWC parents of this study appeared to give their children room to 'follow their own path', it is suggested that, as they grew older, students' attempts to gain entry to the 'adult sphere' resulted in them developing dispositions which were increasingly classed, racialised and gendered. Bodovski (2013) argues that, as young people enter their teenage years they have a growing awareness of their social positioning and the limitations associated with it, therefore adolescence can be argued to be a critical phase in reaffirming the social agent's habitus. This is best exemplified in the cases of Connie and MacTavish, who it is argued closely embodied traditional, gendered WBWC dispositions during adolescence: Connie through her expression of hyper-femininity and performance of caring practices; MacTavish through his focus on being 'active', particularly in sports, and being responsible for his family while also doing his 'own thing'. Both participants spoke of being 'too grown up' for out-of-school science activities in secondary school and both expressed fairly straightforward answers regarding not continuing to study science i.e. because they preferred other subjects.

The reasons given by the other participants who chose not to continue with science were less clear-cut; many of them appeared to have considered taking a science A Level, but for various reasons decided not to. It is argued that this was due to a tension these students were experiencing between enacting a 'grown-up' WBWC habitus and engaging in science. What seemed an uncomplicated decision for Connie and MacTavish was less so for other participants, depending on how closely they subscribed to traditional WBWC dispositions. This echoes similar findings in Ingram (2011) study where she describes working-class students experiencing a 'destabilised habitus' when the simultaneous pull by the forces of two incompatible fields causes an internal conflict, which is often masked by ambivalence. The WBWC students in this study appeared to sense incompatibility between the world of science – which the quotes above demonstrate was constructed by them as academic, difficult and

often without obvious use-value – and their home world, which does not tend to include science but values practical knowledge which is applicable to everyday life and future career aspirations.

According to Ingram (2011), a habitus tug can generate suffering for individuals caught between two opposing fields, with a potential to destabilise the habitus to the extent that they are not 'a fish in water' in either. Under such conditions, the students in this study appeared to resolve this tension by aligning their habitus with dispositions which are at home in either the (masculine, middle-class) field of science or the (WBWC) field of home. Most participants (consciously or otherwise) chose the latter, although it was not necessarily an easy process. This is evidenced by Danielle, who self-excluded from her school science/STEM club and, eventually, from participating in Physics at A Level (*see also* Chapter Seven). Football Master and Bobster chose to embrace the cerebral dispositions associated with middle-class masculinity, which enabled them to be a 'fish in water' in the school-like field of their science/STEM club but made them 'outsiders' amongst their peers. However, as will be discussed in the next chapter, a drop in science attainment for Bobster resulted in a disruption to his cultivated habitus, and he no longer felt 'at home' in either field.

The exception to this pattern is LemonOnion, who appeared to manage her habitus tug by preserving her academic dispositions (aligned with cold, abstract, theoretical expertise) in her school environment and her practical dispositions (aligned with hot, practical, personal expertise) in her home environment. It is argued that LemonOnion's strict management of the two conflicting sets of dispositions within her habitus enabled her to suppress whichever set was not dominant in the current field in which she operated. However, Chapter Seven will show how this habitus 'management' wasn't sustainable and LemonOnion eventually withdrew from the academic Biology A Level to take up an applied science course at college.

Bourdieusian theory proposes that an individual's dispositions are developed through the *early* and *long-term* exposure to, and subsequent internalisation of, social structures through socialisation (Bourdieu, 1998). The interview and survey data presented in this chapter has indicated that WBWC students do not tend to experience long-term exposure to out-of-school science, due to classed, racialised

and gendered approaches to leisure time; even the students of this study whose parents had previously shown an advocacy for science at home. It is argued that the earlier potential for these particular students to internalise a disposition which saw engaging in science as 'normal' for people like them was disrupted as parents became more passive during their child's adolescence. Indeed, students' out-of-school activities became increasingly aligned with 'typical' WBWC practices, illustrating that WBWC dispositions were being reproduced within the students themselves, which subsequently pushed them further away from science both in school and out.

Nevertheless, the interview data have demonstrated WBWC approaches to upbringing and values on knowledge are not the only mechanisms operating to generate tendencies for WBWC students to choose not to continue studying science. The experiences of participants such as Danielle and Bobster demonstrate that the positive effects of (parent-supported) out-of-school science engagement can also be undermined by students' negative experiences in school science. Meanwhile, the case of Football Master shows how the early development of scientific dispositions is not necessary to feel 'at home' in school science, as long as one holds the relevant dominant science-related cultural capital with exchange-value i.e. high science attainment and 'cold' forms of scientific knowledge, and the middle-class masculine dispositions to leverage them in school-like science fields. This is similar to findings by Carlone, Webb et al. (2015) who argued that being interested in science is useful, but not an essential part of boys' identity performances and recognition work in science. As this chapter has shown, the same cannot be said for the WBWC females of this study, who were much more likely to convey a lack of self-confidence in their abilities and entitlement to science-activities. As will be argued in the next chapter, gender also plays a significant role in how WBWC students engage with science in the school-based science field.

6.7. Summary

This chapter has presented interview and survey data to explore WBWC students' later engagement with out-of-school science, showing that as participants grew older, their engagement diminished substantially. Most participants reported minimal engagement, apart from occasionally watching science TV programmes,

while a minority – two male participants – reported regularly attending their school science/STEM club. It was argued that these patterns of engagement were reflective of increasingly gendered, classed and racialised dispositions enacted by participants as they entered adolescence, dispositions produced as a result of their parents' own classed and racialised approaches to child-rearing, which left students to 'follow their own path'. The lack of 'natural' place for science, and scientific expertise, in the WBWC home was suggested to be a mechanism which resulted in WBWC students tending to see out-of-school science as 'not for people like them'.

Further analysis of the interview data suggested that students experienced a 'habitus tug' between the opposing fields of their home and the world of science, which was now represented by school and school-like activities. Most of the participants resolved this tension by aligning themselves with 'grown up' WBWC dispositions, dispositions which were more overtly gendered, classed, and racialised than demonstrated in primary school, and subsequently distancing themselves from the world of science. Conversely, two male participants resolved the 'habitus tug' by reflexively aligning themselves with cerebral, middle-class masculinity and rejecting the physical masculinity usually associated with White working-class males; this enabled them to flourish in science fields as 'a fish in water'. Finally, one female participant managed to feel comfortable in school science by keeping her WBWC dispositions confined to the field of home, although this involved self-excluding from out-of-school science activities which were too school-like, such as the school science/STEM club.

The chapter concluded with a discussion regarding the mitigating influence school-level factors appeared to have on WBWC students' positive experiences in out-of-school science, concluding that ongoing science participation appears to be related less to the development of early scientific *dispositions*, as to early familiarity and accrual of science-related cultural capital with exchange-value and the (middle-class masculine) dispositions to leverage them in the field of school science. As evidenced by Football Master, this facilitates a habitus which feels 'at home' in science, to the extent that he is keen to continue studying science even to university. Meanwhile, female students like Danielle, who had expressed scientific dispositions throughout

the study, lacked self-confidence in their school science field and ultimately self-excluded from ongoing science participation. The next and final data chapter explores these school-based factors in further detail.

7. Double Science is 'the main option for students like me' - Analysing WBWC students' 'choice' of GCSE science award

7.1. Introduction

In exploring the dynamics involved in WBWC students' choice/non-choice of science A Levels we have seen in the first two data chapters that out-of-school science engagement does not satisfactorily explain what may cause the under-representation of WBWC students in post-16 science fields, however the data suggested school-level factors may provide greater insight. The strong relationship between the choice of Triple Science and ongoing science participation (as discussed in Chapter Two) and the negative impact this 'streaming' appeared to have on two of the study participants, who had otherwise intended to continue studying science, directed me to investigate this feature more widely within my data. The final data chapter of this thesis, therefore, explores White British working-class (WBWC) students' choice of science award at GCSE and reflects on the implications of this decision for students' participation in science A Levels.

This chapter describes participants' rationales for choosing Double or Triple Science. I will show how Double Science was reported by most WBWC students as the standard option for students like them and therefore 'good enough' for their needs and 'achievable' compared to Triple Science, even for a participant who had consistently held aspirations to continue with science at A Level. The chapter also reports on a minority of WBWC students who recounted their choice of Triple Science as the obvious choice for 'top' students like them because of the prestige associated with the award and describes the emotional toll experienced by a participant who was dropped from to Double Science when he failed to maintain academic standards.

Analysis of the interview data found that WBWC students who took Double Science tended to focus on the *use-value* of this GCSE pathway, while the WBWC students who took Triple Science spoke of the strategic *exchange-value* afforded by that particular route. It is argued that this represents a risk-management approach by WBWC students – which is reinforced by the school – who are more likely to pursue

the qualification with a higher likelihood of success and more obviously meets their needs in the short term. This also reveals how schools can work to socialise some WBWC students – in particular male students – to welcome the long-term gains associated with Triple Science and the symbolic violence which occurs when WBWC students are steered away from this prestigious qualification.

Furthermore, the 'hands-off' parenting style as discussed in the previous data chapters was also seen in how WBWC parents tended to approach their involvement with students' choices within school. It is argued that their general faith in the guidance of their child's teacher meant that WBWC students were more susceptible to 'pedagogic action', which nudged them towards taking Double Science, regardless of prior attainment or interest in science. Participants recalled a range of different school approaches to accommodating Triple Science, revealing they were much more likely to be in a position of disadvantage regarding access to this route. The WBWC dispositions of 'knowing one's place' and lack of familiarity with the middle-class field of education meant that such disadvantages were not challenged but accepted as 'the way things were', thus contributing towards the (re)production of the WBWC habitus.

In this chapter I argue that the use of differential science routes is a significant factor contributing to the under-representation of WBWC students in post-16 science participation. This is due to the interplay between the uneven field in which these White British working-class students were placed regarding their school's accommodation for Triple Science; the increased likelihood of them not having the requisite cultural capital (attainment) to be granted access to Triple Science when it is available; their greater susceptibility to pedagogic action directing them to Double Science; and dispositions associated with the White British working-class habitus, such as 'not rising above one's station', suggested to be in tension between the prestigious status of Triple Science. The result is that more WBWC students take Double Science than Triple Science, while the reverse is true for students from other sociocultural backgrounds. As Triple Science is seen as the best preparation for the study of science at A Level this has significant social justice implications for science participation at A Level.

This chapter reports an analysis of the year 6, 8, 9 and 11 student interview data sets and year 6, 9 and 11 parent interview data sets; the interviews are contextualised by data from the year 11 survey. Data were analysed with a Bourdieusian conceptual lens, to explore decision-making in the Double vs. Triple science route along class, gender and racial lines. The coding framework for the analysis, consisting of descriptions of the themes found and relevant data extracts, can be found in the appendices.

7.2. Double Science - the 'main choice' for White British working-class students

The majority of students in the study (nine of twelve) took the Double Science route at GCSE, with most of those students (seven of the nine) reporting that the choice was their own, rather than the school's. Analysis of the interviews uncovered a number of dynamics at play in students following the Double rather than the Triple Science route, dynamics which will be examined in detail in this section. The section is divided up into three parts; the first two discuss the two main discourses participants conveyed when describing their rationales of why Double Science was the 'appropriate' route, whether they chose it or not. These are presented discretely for the purposes of clarity, but there was overlap between some participants' use of these discourses as will be discussed further below. The third part of this section explores students' experiences of the selection process, in particular examining whose advice they drew on when 'choosing' Double Science.

7.2.1. Double Science is the 'standard science route for students in our school'

One of the most common themes in the year 11 interview data regarding students' personal choice of Double Science over Triple Science was the suggestion that students rationalised Double Science as the standard option, and thus a 'sufficient' science award:

> (I chose Double Science) because in the school that's like the main one you have to do if like *even if you don't take it as an option*. That's the main thing you have to do.
>
> (Connie, female, year 11, emphasis added)

You already have to do science, there's no point in me doing Triple Science because I could do like … I think I chose Art instead of Science, because *I'm already doing science, so why would I do (Triple Science)*?

(Charlie, female, year 11, emphasis added)

Indeed, this discourse was also apparent for one of the students who reported he didn't have a choice in taking Double Science:

Hedgehog - The school decided…

I - Okay. And are you happy with taking Double Science?

Hedgehog - Yeah, *I'm fine with it*… Accounting doesn't really come in the science department. And if I can get a C in science I'll be happy with that, because I just know it's a pass.

(Hedgehog, male, year 11, emphasis added)

Hedgehog's apparent satisfaction with taking Double Science appears to be related to his position that passing that qualification has sufficient *use-value* for his planned future career in accountancy, and it is suggested that both Charlie and Connie occupied similar positions. As discussed in Chapter Six, a number of the WBWC mothers failed to recognise the exchange-value of their medical knowledge, instead imbuing it with use-value. It is argued that these findings reveal that WBWC students (and their parents) tend to value knowledge and qualifications with the greatest recognisable use-value in the *short-term* – recalling the working-class dispositions of a 'taste for necessity' (Kowalczyk, Sayer et al., 2015; Lyons, 2006) discussed in Chapter Two. As will be explored further below, Double Science is likely to be seen as a less risky option than the long-term exchange-value associated with the more difficult – and elusive – Triple Science.

Charlie's quote also hints at timetable restrictions within her school which meant doing Triple Science would result in her losing one of her GCSE options. Several other participants commented on this factor when discussing their choice of Double:

The option wasn't Double or Triple. The option was 'do you want to do science as an option?'… You get the choice to do Triple Science, but it's in one of your three options.

(Danielle, female, year 11)

> I think (I chose Double Science) because at the time I liked PE and I liked Art, so it was either pick (Triple Science or one of them).
>
> (Dave, male, year 11)

When faced with the decision to use up a GCSE option to take Triple Science or to opt for the Double Science route and an additional GCSE in a different subject, many of the students in the study chose the latter. This was presented as a straightforward decision on their part, particularly as these students did not see themselves pursuing science at A Level. Double Science allowed them to have 'the main science qualification' while also pursuing another subject they enjoyed.

A similar constraint appeared in another student's interview, as MacTavish explained that Triple Science was not accommodated in his school timetable at all, and would therefore require students to forego some of their free time:

> I wanted to do Double (Science) initially anyway… for Triple Science at our school you have to attend a two-hour session on a Monday after school.
>
> (MacTavish, male, year 11)

As discussed in previous chapters, MacTavish was amongst the majority of WBWC students who tended to consider their leisure time as valuable to the point they would not consider sacrificing it for activities which may give them an educational advantage. Thus, it is unsurprising he reports this timetabling issue as a major obstacle in him taking Triple Science. It is notable that his account in year 11 includes a statement that he had already decided to take Double Science, marking a contrast to his earlier, more aspirational views on the same issue:

> (I'm going to do Triple Science) because I'm in top set and *obviously that's the best one* to take so I took that.
>
> (MacTavish, male, year 9, emphasis added)

MacTavish's previous description of Triple Science as 'obviously the best' route suggests he constructed Triple as a superior science award to Double Science, and subsequently wished to follow that route. His ultimate decision to take Double Science implies the timetable limitations he associated with doing Triple Science (as per the above quote from his year 11 interview) may have deterred him from taking that option. In his year 11 interview MacTavish went so far as to retrospectively revise

his narrative of Double/Triple Science choice, stating he 'wanted to do Double initially anyway'.

MacTavish was not the only student to alter his account regarding the decision to choose Double Science. While in year 9, Charlie also talked of being in the top set for science and hoped to do Triple Science because she liked science and found it interesting[3], however by the time she was interviewed in year 11 her recollection of this period had changed considerably:

> I didn't really like science when I was in year 9. It was kind of boring and I didn't really have the teacher, so I was just like no I can't be bothered… Yeah, um, it would've taken up … because we do five hours over two weeks of an option, so it would be… I would do four hours, so that's eight, which is – oh my God – 13… hours of science over two weeks *I could not do that*.
>
> (Charlie, female, year 11, emphasis added)

Charlie's new perspective on her choice of Double Science was that she had not liked science as a subject, and to drive her point home she emphasised what she articulated as an excessive time commitment required to do Triple Science as a result of it being one of her GCSE options. Like MacTavish, the timetable limitations surrounding the Triple Science route appeared to put Charlie off from taking it, despite having expressed a desire to do so in earlier interviews and apparently having the prior attainment to do so.

'Making do' with unequal access to Triple Science

The social justice implications of such restrictions for participation in science become apparent when one considers that these students were managing their choice of the Double or Triple Science routes under conditions which were not equitable. As discussed in Chapter Two, lack of access to Triple Science may be a factor in why academically-able young people from deprived communities are less likely to take that science route than their more privileged peers (The Sutton Trust, 2015). The findings from this study appear to corroborate this argument. It is possible that students such as MacTavish and Charlie, who were both in the top sets for science in

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[3] Recorded as field notes

year 9, may have stood by their earlier decision to choose Triple Science had they not been required to sacrifice a GCSE option or give up after-school time to do so.

Using a Bourdieusian lens, it is argued that the differential approaches used by schools to accommodate the Triple Science route reflects the uneven field in which students are operating. As Bourdieu argued, the field is determined by sets of distributional and differentiation principles made of properties (capital) relevant to that particular social space. These properties are a 'field of forces' or 'objective power relations' that are active on all members of the field. Agents and collectives of agents are then defined by their relative positions within social space (Bourdieu, 1985b). In the context of this study, White British working-class students are largely perceived to lack the relevant cultural capital (prior attainment in science) relevant to access Triple Science and are consequently situated at a disadvantage within the secondary school science field, relative to students from middle-class backgrounds and some Minority Ethnic (especially Asian) backgrounds who are more likely to be considered as 'good pupils' or 'naturally clever' (L. Archer, DeWitt et al., 2015; Wong, 2012). This position begins to define WBWC students as being less suitable for Triple Science than their peers and access to this science route is limited accordingly.

In such conditions, students such as MacTavish and Charlie, who had otherwise expressed an interest in taking Triple Science and appeared to have the ability to do so, displayed 'making do' attitudes typically associated with the production of the White working-class habitus such as 'a virtue made of necessity' (Bourdieu, 1990). Taking Double Science was deemed the sensible option, and their previous desire to take Triple Science was revised.

7.2.2. Double Science is 'achievable'

The most common thread running through the year 11 interviews regarding students' personal choice of Double Science over Triple Science was that of the perceived difficulty of Triple Science:

> When I got to (school)… it would have been core science that you have to do, or Triple Science. But I think that (Triple) would have been a bit too much for me.

> (Lucy, female, year 11)

They said if you wanted to do (Triple Science)… but I didn't want. I didn't know what it was about, and I don't think I could have handled it as well… Cos some of… the smartest people in our year… like do it… And they still find it hard. So, *if they find it hard, like imagine what … it would just be like twice as hard for me I guess*.

(Celina, female, year 11, emphasis added)

They gave us an option to do Triple Science, but *they did obviously say it's pretty difficult* because you have to do all three… Well there's like different days that are allocated for Triple Science and (Double Science is) also easier when it comes down to it and less pressure-ish, but it's easier when you only have to focus on two rather than three.

(MacTavish, male, year 11, emphasis added)

I could do Triple Science, but I didn't really … I was getting a C grade and everyone who's doing Triple seems like they're getting like As and stuff like that.

(Dave, male, year 11)

Triple Science is too hard… I wouldn't have done it. I'd have failed it, so there was no point.

(Danielle, female, year 11)

This narrative also appeared in Millie's account, who had no choice but to take Double Science:

Millie - I'm in set 2… I think we were just all put in for it. We all just, we just knew that we had to do it and it wasn't really discussed. It was just you're doing it, and no one really disagreed with it…

I - Okay, um, were you happy being selected for Double Science?

Millie - Yeah, *I'm fine with it*. It doesn't really bother me. I mean it's hard and I do find it difficult, but I don't have a problem with it at all.

(Millie, female, year 11, emphasis added)

In contrast to the argument of Double Science being 'the main option', which mostly emerged in the later year 11 interviews, the theme of Triple Science being 'too hard' was present in a number of the students' year 9 and year 11 interviews, indicating it was a factor for students at the time of their choice to do Double Science:

I don't think I'm good enough to do the Triple.

(Danielle, female, year 9)

I wouldn't do (Triple Science), it's too complicated.

(Celina, female, year 9)

> I could do Triple Science, but I prefer just to do Double, 'cos I find it easier…
> Just so I can take in as much as I need, apart from having another one where
> I get all of them confused.
>
> (Dave, male, year 9)

> Obviously you can pick… Triple Science but you have to be in the top set for
> science and I'm in the second set and you have to be getting like sevens,
> which is like the equivalent to a C or a B in GCSE terms… and I'm like D/C
> sort of thing… and I wouldn't pick that cos I don't think I'd get that good in
> it.
>
> (Millie, female, year 9)

In year 11 there were no instances where participants contradicted earlier statements regarding Triple Science being too difficult. The consistency of students' views demonstrated a sense of justification in their choice to do Double Science, as it was sufficient for their needs and meant they could avoid the additional 'pressure' which came with taking Triple Science. MacTavish's report suggested that such demands were highlighted to students by their teachers, something which also emerged in the parent interviews:

> I think she's not going to go for like Triple Science or anything, but to be fair,
> the lady that we spoke to again at the parents' evening was really nice and
> really good, *she said 'I wouldn't recommend it to anyone really*, I'd
> recommend that they all start off with Double Science… and then you go
> into the Triple Science you know further down the line'.
>
> (Florence, Lucy's mother, year 9, emphasis added)

> They asked her which one she wanted to do, and she was 'I don't know if I
> can do Double Science' *the teacher said, 'Yes you can, you can do that, you'll
> be able to do (Double) easily'*... But I think (Triple Science) involve(s) too
> much work, and for her because of where she is it wouldn't work.
>
> (Sandra, Danielle's mother, year 9, emphasis added)

Several parents in the study expressed concern regarding the mental health of their children, particularly the girls of the study, and the stress associated with exams. When interviewed again when the students were in year 11 these parents largely felt satisfied with their child's choice of Double Science because it involved less pressure than Triple Science and as a result this would be more likely to lead to a good exam result:

She is doing… Double… Because they said to her she was struggling… she's gone better, because she's 'Oh I'm just doing Double, I feel better'. I think well then *she's got more of a chance, hasn't she*?

(Sandra, Danielle's mother, year 11, emphasis added)

According to her mother, Danielle was described by her teachers as 'struggling' in science while in year 9. She had been in set three for science at this time, the year the streaming into Double or Triple Science begins, suggesting Danielle's prior attainment meant placement in Double Science may have been the appropriate route for her to take. Nevertheless, the picture of Danielle's attainment in science was more complicated than it appeared from Sandra's report of teacher feedback, more of which will be discussed in section 7.3.3.

Double Science is the 'less risky' option

Aside from the three students who chose Triple Science at year 9 (Football Master, LemonOnion and Bobster - who will be discussed later), the students in the study tended to describe themselves as 'middling' students, some of them even in primary school. However, having average attainment does not necessarily denote lack of ability. Stahl's (2016) study found secondary-age White working-class boys aiming to be academically average and 'no better than anyone else' in order to be authentic to White working-class social values of solidarity, and less at risk of academic failure. It appears that this dynamic may have also been at play for many of the students in this study, with the perception that Double Award science was the less risky, 'main one', which most students took, even if they may have had the ability to be academically successful in science.

Two of the three students in the study who cited the perceived difficulty of Triple Science as their *main* reason for choosing Double Science seemed to have the requirements for access to the Triple Award while in year 9. Lucy was in the top set of science in her school, usually considered a strong position for access to Triple Science, but chose not to take it because Triple 'would have been a bit too much', while Celina stated she was asked if she wanted to do Triple by her teacher but decided against it because she 'couldn't have handled it as well' as Double Science. The third student, Danielle, will be discussed further later in the chapter, but it

appeared that she was mid-point in the process of working her way up from the bottom set of science to the top. Lucy and Celina's lack of confidence in their academic ability in science suggests that they did not feel they belonged in Triple Science.

It is argued that these WBWC female students' decisions not to take Triple Science is indicative that they were receptive to discourses which present science as the province of the 'middle-class masculine intellect', as discussed in the previous chapter. Other studies have argued that by being working-class and embodying working-class culture, students experience barriers to educational success and such barriers are only surmountable if students can surmount *being* working-class and instead *perform being* middle-class (Ingram, 2011; Willis, 1977). Chapter Six discussed the tension and 'suffering' caused by the production of a habitus constituted of dispositions generated from two incompatible fields – such as that of the working-class family background (usually situated in a deprived neighbourhood) and the middle-class school system (Bourdieu, 2000; Ingram, 2011). The field of school science has been argued to be particularly aligned with middle-class dispositions and 'ways of being' (L. Archer, Moote et al., 2016a), and thus it is suggested the 'tug' between (White British) working-class students' dispositions would be especially acute in this subject.

As we will see later in the chapter, producing dispositions at ease in school science was challenging but possible for the two male participants who opted to take Triple Science. However, Celina and Lucy had the added 'disadvantage' of being female, for whom it is perceived success in science comes as a result of hard work, rather than the 'innate ability' associated with masculine performances of academic success (L. Archer, Moote et al., 2016a; Ingram & Waller, 2014). In Ingram's (2011) words, they would have to 'overcome' their White working-classness *and* their femininity in order to produce dispositions within their habitus which were at ease in the masculine, intellectual world of science. Ultimately they found this level of work unachievable and as a result did not deem themselves to be 'educationally worthy' (The Runnymede Trust, 2009) to do Triple Science.

It is suggested that for most students in this study, aiming for pass grades via the 'less demanding' route of Double Science was the safest option, while Triple Science was perceived as a high-stakes route, with a high risk of failure and little obvious reward. Indeed, there was a notable absence for these students, in both the student and parent interviews, of any discussion of the advantages or 'exchange-value' associated with Triple Science. This implies that for the majority of WBWC students in the study, such advantages were not necessarily communicated to them by teachers and their subsequent 'choice' to take it over Triple Science was not necessarily well-informed.

Too timid to challenge the school?

As a consequence, it is perhaps not surprising that none of the students or parents reported confronting the school regarding being 'pushed' by teachers towards Double Science. Sinead was the only parent who mentioned specifically wanting their child to do Triple Science. Her daughter, Millie, was also one of the few students who reported that the school made the decision for her to do Double Science. Despite expressing frustration regarding her daughter's lack of choice, Sinead didn't take it forward:

> I had originally wanted her to go for Triple Science, which she wasn't particularly interested (in)… But then I also found out, out of the 103 or something in that year only 17 are asked to do Triple Science… *They don't even have that choice of doing it*. The options are not there, which is a shame you know, but again *it was something she would have to work out and apply herself*.

> (Sinead, Millie's mother, year 9, emphasis added)

Sinead's account gives further evidence of how schools manage resources for Triple Science differently. In this case, only a very small minority of students, those in the top set, were offered the opportunity to take Triple Science. Millie's placement in the second set appeared to imply that she would not be offered the option. Despite past examples of Sinead challenging decisions by the school regarding her daughter's education and exerting her influence on Millie's GCSE subject choice to ensure she was doing 'strong enough' subjects, she appeared to be resigned to the fact that the odds were against Millie being able to take it and thus didn't attempt to intervene. Sinead justified not challenging the lack of choice given to all students by framing it

as Millie's responsibility to work out for herself and explaining that Millie 'wasn't particularly interested' in Triple Science. This perspective exemplifies the 'watchful and concerned' approach Lareau (2011) found in her study of classed approaches to parenting, which observed a pattern of working-class parents 'desperate' for their children to do well, but feeling unable to intervene.

Such findings point to attitudes associated with the production of the White working-class habitus, that of 'not rising above one's station' (Bourdieu, 1987). Bourdieu described the dispositions developed through one's social position as prompting the social agent to 'keep their distance' from others in different social positions; such 'social distances', he said, are inscribed in the body as 'arrogance' or 'timidity' (Bourdieu, 1987). For the White British working-class students of this study (and their parents), the Double Science and Triple Science streams became a proxy for social positions within the school field. When reminded by teachers of the 'appropriateness' of Double Science, many of the students became timid and wary regarding the choice of Triple Science, even if they had expressed an interest to take it at some point in the past.

7.2.3. Double Science is 'my own choice to make'

The other notable finding regarding students' 'choice' of Double Science was that only one of the students talked about discussing their decision with their parents, and this was a passing reference. Overall, only two students in the study explicitly mentioned discussing their choice of science award with a parent, the other student, LemonOnion, chose to take Triple Science after encouragement from her mother, more of which will be discussed later. Students often remarked that they were interested in their parents' opinion on subject choice in general because they felt that their parents had their best interests in mind, but there was a clear gender divide in the study as a whole as to how much students would allow their parents to influence their decisions, with male participants more likely to report that a teacher's guidance was more valuable, or that they would base their choice on their opinion alone:

> I - who would you go and talk to about what subjects you should be taking, or you might take?
> Hedgehog - Like mum and dad or someone, yeah, or like a teacher.

I - Why would you go to your parents, do you think?

Hedgehog - I don't know, it's like … I don't know, no, probably just the teacher.

(Hedgehog, Double Science, male, year 8)

(I would speak to my) parents and then the people at the college on the open evenings (to make decisions) ... My parents probably more so, because I care what they think, but the college, *they know what they're talking about.*

(Football Master, Triple Science, male, year 11, emphasis added)

I have (spoken with my family about subject choices) slightly, but it's for… in my eyes, it's based on my opinion really, like what I want to do.

(MacTavish, Double Science, male, year 11)

The female participants, in contrast, tended to express being more invested in their parents', particularly their mother's, opinion:

I'll talk with my mum about *what she thinks I should take* and what will be good for me to take so I'll talk to her.

(Connie, Double Science, female, year 9, emphasis added)

I'll just ask my mum *what she wants me to do*.

(LemonOnion, Triple Science, female, year 8, emphasis added)

(I spoke to) my mum. She isn't too happy about Food Technology as she doesn't think it's a strong enough subject… And I agree with her because like it doesn't sound very strong, Food Technology, it's not that good but like, yeah, I talked to my mum about it and she agrees with the Business Studies and Philosophy and Ethics. She thinks they would help with what I want to be.

(Millie, Double Science, female, year 9)

By looking to their mothers to guide them to make the 'right' choice, it is argued that the girls' were constructing themselves to perform a suitable, mature identity i.e. a traditional White working-class feminine identity, with a sense of obligation and strong ties to their families, rather than being autonomous and independent (L. Archer et al., 2007a; Skeggs, 1997). Meanwhile, the boys appeared to position themselves as performing a hegemonic form of masculinity, where they take responsibility for making the 'right' decision for themselves (Connell & Messerschmidt, 2005; Ingram & Waller, 2014).

Regardless of the extent of students' discussion with their parents on the choice to do Double or Triple, when interviewed in year 11 half the parents did not know which option their child was taking:

> I think she's on Triple, isn't she? Is she Double or Triple? I'm not sure. I think she might be Triple.
>
> (Shelly, Connie's mother, year 11)
>
> I - What's he taking in terms of his science option? Is it Double or Triple or…?
>
> Marigold - It's all of them… Triple.
>
> (Marigold, MacTavish's mother, year 11)
>
> I think it's Double… I think it was because of her grades she had to take … might be Triple even, I don't know.
>
> (Robyn, Charlie's mother, year 11)
>
> I - Do you know what option he's taking for science? Is it Double Science, Triple Science?
>
> Larry - Oh I don't know other than 'science', you'd have to ask him.
>
> (Larry, Hedgehog's father, year 11)
>
> I think it's Applied… I'm not sure – it's either Double or Applied.
>
> (Florence, Lucy's mother, year 11)

All of the students mentioned above were, in fact, studying Double Science. The lack of clarity these parents had regarding the science option their child had taken suggests that these parents were generally satisfied to allow their children to follow whichever route they thought best. This resonates once again with Lareau's (2011) study, where working-class families would approach child-rearing through the 'accomplishment of natural growth'. Again, this contrasts with students from middle-class or Minority Ethnic working-class backgrounds, whose parents are more likely to monitor their child's education in order to reproduce educational success (Francis & Archer, 2010).

It is argued that schools' differential and often opaque selective processes around access to Triple Science, accompanied by teachers' pushing of more WBWC students towards Double Science than the Triple Award, is an example of what Bourdieu called *Pedagogic Action* (Bourdieu & Passeron, 2000) (*see also* Chapter Three). In other words, the cultural arbitrary, or 'way things should be', communicated to most WBWC students by their school was that Double Science was the most appropriate

option, compared to students from more advantaged backgrounds who are more likely to be advised that Triple Science is the 'norm' (L. Archer, Moote et al., 2016b). It is argued that the White British working-class tendency to 'let things be' and 'not rise above one's station' meant that these WBWC students were more susceptible to such pedagogic work, compared to middle-class parents who are more likely to challenge school decisions they believe will disadvantage their child (Ball & Vincent, 2001; Lareau, 2011).

7.3. Triple Science – an option for the 'special few'

Only three of the twelve students in the study opted for the Triple Science route. All three students stated they made their decision following receipt of a formal invitation (via letter) to take it by their school. Interviews with these students uncovered the reproduction of discourses somewhat similar to peers taking Double Science (as discussed in the previous section), except these discourses advantageously positioned the three students in question as the 'exception' to other students and 'exceptional' in their academic ability. The section is again divided up into three parts. The first discusses the main discourse these three participants conveyed when describing their rationales of why Triple Science was the 'obvious' choice. The second and third parts focus on the experiences of two particular students, whose cases are used to illustrate how the process of streaming into Double or Triple Science routes negatively affected students' aspirations to continued science study at A Level: Bobster, one of the three participants mentioned above, who began Triple Science but was subsequently dropped to Double; and Danielle, who chose Double Science but had wanted to take a science subject at A Level. The section begins with a discussion of the three students' who opted for Triple Science expressions of the discourse that Triple Science was the 'superior' science route, arguing that students had to undertake considerable identity work in order to achieve a sense of belonging in this 'elite' club.

7.3.1. 'When you are offered Triple Science, you don't say no'

Throughout the interviews, student participants consistently associated Triple Science with being exclusively for the most academically able students within their school:

> If you were in top set, you take Triple Science.
>
> (MacTavish, male, year 9)

> I was getting a C grade and everyone who's doing Triple seems like they're getting like As.
>
> (Dave, male year 11)

> You have to be in the top set for (Triple) Science and I'm in the second set and you have to be getting like sevens, which is like the equivalent to a C or a B in GCSE terms… and I'm like D/C sort of thing… *I'm not in the right group.*
>
> (Millie, female, year 9, emphasis added)

The three students in the study who chose to do Triple Science were in the top set of science in their school, and therefore considered to be in 'the right group'. These students received a formal invitation to take Triple Science from their school, and their choice was to accept or refuse the offer:

> I'm doing Triple Science… I got (a letter) and my mum said I might as well try
>
> (LemonOnion, female, year 9)

> *I didn't decide to do it*, but they sent me a letter saying I could do it if I want and I wanted to do it because it's an extra GCSE and I really like science.
>
> (Football Master, male, year 9, emphasis added)

> (Triple Science) was offered to me and I just couldn't say no, because I do love science and it's another two GCSEs on top of what I'm already doing… Plus we do a whole, you know a whole GCSE on like physics and chemistry and biology. Yeah, *I like the idea of doing (Triple) science*.
>
> (Bobster, male, year 9, emphasis added)

Given the opportunity to refuse a place in Triple Science, none of these students decided to – it was 'too good to say no'. Bobster and Football Master particularly expressed an enthusiasm for subject, stating they 'really like science' and 'I do love science'. These two male students also indicated a recognition of the *exchange-value* of the Triple Science award; not only did it bring the material advantage of an additional qualification, they were aware of the prestige Triple Science carried in the educational field and 'liked the idea of it'. As there is no indication these ideas came

from students' parents, it is suggested that the school was reinforcing a discourse of Triple Science as a desirable qualification. LemonOnion, meanwhile, did not discuss the advantages she saw with taking Triple Science when interviewed in year 9, merely saying she 'might as well try' to do it.

As early back as primary school, while their peers described their attainment as average and 'ok', the three students who chose to take Triple Science were the only ones who reported that they were doing 'well':

> I'd say I'm probably (a) good (student)… I always got good grades.
>
> <div align="right">(Football Master, male, year 6)</div>

> *I'm touching excellent*, because basically what I've got to pick up on is my spellings.
>
> <div align="right">(LemonOnion, female, year 6, emphasis added)</div>

> (I'm in the) top groups… We did a science test which I got 65, top… I got 20 out of 20 in my Maths… And um … we also did a literacy test a while ago to find out grades – I got top in that as well.
>
> <div align="right">(Bobster, male, year 6)</div>

Aligning the habitus 'exceptionalism' through the choice of Triple Science

It is argued that the pedagogic work undertaken in students' primary schools socialised these students to align themselves with being the 'top' of school and to be comfortable with being considered 'excellent'. This work continued when they were all placed in the top groups for science (and other subjects) while in secondary school. Thus, when introduced to the idea of the Triple Science award and the selective practices which accompanied it, they were not put off. The three students had internalised the discourses of science being for the 'best and brightest', resulting in the production of a habitus congruent with middle-class exceptionalism, in contrast to the valued egalitarianism of their 'middling' peers (Stahl, 2016).

The male participants seemed to find this placement at 'the top' an easier fit than LemonOnion, with Football Master accepting it without question:

> Football Master - I'm in Triple Science, so that's all of them.
>
> I - Okay, and was that your decision or …?
>
> Football Master - No, they put you into that set.

I - Are you happy with that?

Football Master - Yeah, I wanted to be in that set.

(Football Master, male, year 11)

While for Bobster, the presence of his friends in Triple Science helped him to feel he belonged:

Bobster - (Being in Triple Science gets) sort of more respect amongst my friends' group, which the majority are in my science group.

I - Right. So, you're all sort of pleased with the fact you do Triple Science?

Bobster - Yeah. I don't think any of my friends could possibly call me a lonely nerd, because it's like one second, you go to this (science) club with me.

(Bobster, male, year 9)

Football Master and Bobster were 'pleased' and 'happy' to be in Triple Science, so accepting their school's invitation was an easy decision to make. There is also evidence to suggest that, as in Francis, Connolly et al.'s (2017) study, being placed in Triple Science (often a proxy for 'top set' science) led to feelings of superiority and entitlement for these two male students, something also demonstrated in Chapter Six when they talked about their experiences in their school science/STEM club. Meanwhile LemonOnion, the female participant, spoke of her consideration to refuse the offer of taking Triple Science but reported being persuaded to 'have a go' by her mother:

(The teacher's) going to be choosing who's going to go into Triple Science but you can refuse it so I'm not sure if I will or not.

(LemonOnion, female, year 8)

What is not clear from the data is whether LemonOnion truly had the option to refuse, or whether the school would have done additional pedagogic work to ensure she said yes. As a high-achieving student, the Triple Science environment could have indoctrinated LemonOnion into the 'correct' (middle-class) science ways, that of additional conceptual 'cold' knowledge, high attainment and competitiveness, thereby reinforcing and reproducing the institution's habitus (Ingram, 2009).

LemonOnion's apparent hesitance about Triple Science appeared again in her year 11 interview, when she reported how she initially challenged her teacher about her placement in the group:

When I got told I was doing Triple Science I was kind of really confused, I went up to my teacher and went 'Sir, how am I in Triple Science? – I didn't do any work in your lessons' and he went 'Your CAT tests were really good, remember when we did them in year 7?' I was like '*So in year 7 I was already smart enough to be in Triple Science*' – what don't I understand about that? So, I kind of just go in and … it's not actually that hard as it sounded… Because the people I'm with in my science class, they're all like slightly smarter than me and I kind of sit next to them, and I'm like … they just help me with everything. And then when I get it and I'm helping them … and I've just understood it more*.*

(LemonOnion, female, year 11, emphasis added)

LemonOnion had pushed back on being considered as an intellectual in the past:

We had a massive assembly about it, and they were saying… *It'll be a really good idea to do a lot of academic subjects*, but in a way, I didn't want to… I don't want to do anything academically because I'm not more of that person.

(LemonOnion, female, year 9, emphasis added)

LemonOnion's quote suggests the sorts of pedagogic work undertaken by her school to guide students towards doing the 'right' kind of subjects, that is, those considered to be 'academic'. Furthermore, her testimony serves to highlight the differential approaches taken by schools in managing school subject choice and selection processes in the Double vs. Triple Science routes. In LemonOnion's school, the main student body were steered towards taking academic subjects through a 'massive assembly', implying that work would also be done to push students with the right prior attainment towards Triple Science (demonstrated in LemonOnion's year 11 quote above). As discussed in the previous section, this contrasts with the experience of other students in the study, such as MacTavish, Lucy and Celina, who were not pushed by their schools to do Triple Science despite appearing to have the requisite prior attainment.

Despite being reassured by her school that she was 'smart enough to be in Triple Science', and apparently flourishing in an academic subject, LemonOnion exhibited a lack of comfort with being explicitly identified as academic throughout her interviews, stating she 'wasn't that kind of person'. She was noticeably less at ease with the elite-ness of Triple Science than her male peers, although as her self-

exclusion from out-of-school science and these data imply, her femininity was not the 'obstacle' to her to the same extent as Lucy and Celina (and as will be discussed below, Danielle). A self-confessed long-term 'tomboy', LemonOnion had disassociated from femininity since primary school:

> I am more naughty (than other girls). Cos they're like girly girls and I'm just like 'Let's get out there and do it'.

(LemonOnion, female, year 6)

As Francis, Archer, Moote, DeWitt & Yeomans (2016) suggested, distancing from femininity and/or performing masculinity was a strategy used by middle-class girls who intended to continue with physics at A Level, and 'girly' femininity is considered hard to maintain in association with science. For LemonOnion, femininity appeared to be less of a disadvantage in the production of a habitus at home in science, than loyalty to her traditional working-class, practical dispositions. As discussed in the previous chapter, LemonOnion, Football Master and Bobster experienced a 'habitus tug' as a result of the simultaneous, opposing pulls of the White British working-class field of home and the middle-class field of science (Ingram, 2011). Football Master and Bobster resolved this tension by aligning their habitus with academic science-related dispositions out-of-school which were compatible with those developed in-school, and rejecting dispositions associated with the physical, practical working-class habitus which dominates the field of home. Conversely, LemonOnion had appeared to cultivate (somewhat unstable) academic dispositions *and* practical dispositions, but managed them within her habitus by suppressing one set depending on which field she was operating in. However, this was not a sustainable strategy. As discussed in the previous chapter, LemonOnion eventually dropped her Biology A Level for a less academically-focussed applied science qualification. It appears that LemonOnion's resolution to the 'habitus tug' brought about by studying science was to reject the academic aspects of the subject and embrace the practical.

Of all the participants in the study, the only student to continue their studies in science at A Level was Football Master, one of only two participants (the other being LemonOnion) to successfully complete the Triple Science award. Bobster, who had previously aspired to continue with science, appeared to be strongly impacted by his

experience of being 'dropped' from Triple Science to the Double Science award. His case will be discussed next.

7.3.2. Triple Science 'leaves no room for failure'

As already discussed, the three participants invited by their school to do Triple Science understood why they were considered by their schools to be eligible for the route. Their prior attainment, expressed through their positioning in the top sets of science, signalled them to be 'smart enough' to be offered the opportunity. Their schools had also undertaken additional pedagogic work to present the elite nature of science as a desirable quality, so students would feel the offer of Triple Science 'too good to refuse'. For Bobster and Football Master this included the encouragement to attend the exclusive school science/STEM club, as discussed in the previous chapter, while LemonOnion was encouraged to choose academic subjects for her GCSEs, as discussed above.

Nevertheless, students' position in Triple Science was by no means secure. The threat of being 'dropped' from Triple to Double Science was present for all, used by schools as a mechanism to ensure students 'towed the line' and maintained their grades (L. Archer, Moote et al., 2016b). This section discusses the case of one of the WBWC students in the study, Bobster, whose struggle to maintain his grades made his position in Triple Science precarious. For Bobster, the threat of being dropped to Double Science was finally executed halfway through his GCSEs:

> I was doing Triple, but I failed my coursework, so they were like yeah you need to go away now… Yeah, *it all kind of went a bit bad*.
>
> (Bobster, male, year 11, emphasis added)

Bobster spoke of this incident in a rather casual manner, however after further discussion it appeared that his repositioning within the school field had done considerable damage to Bobster's aspirations. Having planned to study architecture at university since he was in primary school, Bobster now claimed he did not want to go to university or pursue an academic career but instead become a police officer; although he couldn't explain why that particular job appealed to him. Furthermore, having said that he 'loved science' in year 9, he no longer talked about enjoying it and changed his mind about studying science beyond his GCSEs:

I - Would (changing to Double Science) affect your attitude about doing science beyond A level? Were you thinking of doing it before?

Bobster - Not really no… It just affected my attitude towards the teacher.

(Bobster, male, year 11)

From this point, Bobster appeared to lose confidence in his academic ability, in sharp contrast to his previous pride over his grades and position as a 'top student' in the top groups of school:

I feel like I'm not getting as high grades as I was… Because *back then it was looking really bright*, like oh I'm going to get these. Whereas I'm like oh, I can get Cs if I try.

(Bobster, male, year 11, emphasis added)

Bobster's school dropped him from Triple to Double Science because his cultural capital (i.e. his attainment) was no longer considered sufficient for the field of Triple Science, so he was made to leave. As the above quote demonstrates, from this point his overall attainment suffered and Bobster no longer considered his future as 'looking really bright'.

It is argued the pedagogic work undertaken by Bobster's school, which socialised him to aspire to be at the 'top' of school and then dropped him from the 'elite' Triple Science, caused Bobster's habitus to become 'destabilised' (Ingram, 2011). Like Football Master, Bobster had undertaken considerable work to produce the (middle-class masculine) academic dispositions congruent with the exceptionalism of science. As mentioned earlier, this had involved the rejection of dispositions associated with White British working-class masculinity and the field of his family background in order to resolve the issue of 'habitus tug' (Ingram, 2011). The durability of the resulting habitus was demonstrated through Bobster's continued aspirations for 'high' grades, despite his reluctant acceptance of his projected pass grade: 'I'm like oh, I can get Cs if I try'.

In interviews with Bobster's mother it became apparent that Bobster's attainment issues in science came as a surprise:

He is clever and he just doesn't bother using it… (The teachers) have said he does hand his homework in, but he's not putting the effort in that they know he's capable of… So, he's lazy… Before you ask they chucked him out

of Triple Science… (because of) lack of interest… He didn't tell me for a week… The teachers phoned me.

<div align="right">(Martha, Bobster's mother, year 11)</div>

Martha's awareness of Bobster's failure only at the last minute demonstrates her classed and racialised approach to child-rearing. Unlike families from middle-class and certain Minority Ethnic backgrounds who are more likely to closely monitor their child's education(Francis & Archer, 2010), Martha admitted she hadn't paid close attention to how Bobster was doing at school:

> I feel I've failed in not keeping tabs on what (Bobster)'s been up to… they probably do have all the tools here for parents to know what's going on, but I don't get told about them, so I don't know.

<div align="right">(Martha, Bobster's mother, year 11)</div>

Unfortunately for Bobster, his mother did not have the access to economic capital and dominant cultural capital required to know when and how to intervene and ensure Bobster 'kept up' with Triple Science. She did not employ the use of private tuition as middle-class families have been found to do (L. Archer, Moote et al., 2016b), or consider moving Bobster to another school with different teachers. Instead, once informed of the school's decision, Martha did not attempt to challenge it. The working-class values of 'whatever will be, will be' found in Stahl's (2016) work were evident in Martha's (albeit frustrated) resignation to Bobster's new position:

> Martha - They dropped the Triple Science, so yeah.
>
> I - And there's no turning back from that now that he's done that?
>
> Martha - No, no, I'm hoping he'll go to college, do a year of Uniform Services or Public Services… and then might have a change of heart and go back to doing what he always said he wanted to do… to something academic.

<div align="right">(Martha, Bobster's mother, year 11)</div>

Rather than having the agency to challenge the school, Martha's deference to their decision was manifested as a result of the continued production of a working-class habitus, brought about by the school's pedagogic work to put Bobster (and his mother, through her 'failure' as a parent) 'in his place'.

7.3.3. Triple Science is for 'good' students

Danielle is a noteworthy example of the classed, racialised and gendered nature of the processes at work in the placement of students in Double or Triple Science. A student who had consistently expressed science-related aspirations throughout the study and spoken of her enjoyment of science both in-school and out-of-school (as seen in the previous chapters), Danielle seemed a likely candidate for Triple Science. It would be expected that the additional breadth of the Triple Science award would appeal to Danielle's self-reported academic interest in science. Nevertheless, like the participants discussed earlier in the chapter, particularly the female students, Danielle didn't believe herself to be capable of doing Triple Science. This section will discuss how the school's pedagogic work acted to exclude Danielle from Triple Science not just based on attainment, but on the grounds of whether she behaved like the sort of student who belonged at the top of science, and how her position as a WBWC female made her more vulnerable to this action.

As discussed in section 6.2.2., Danielle rejected the idea of her taking Triple Science throughout the study based on her perception that she was 'not good enough' and would 'have failed it'. Indeed, Danielle had been described by her teachers as 'struggling' in science, implying she did not have the prior attainment to be eligible for Triple Science while in year 9. At this point Danielle was in the third set for science, but she had plans to move up to the second set through hard work:

> I think I've done a bit better at science, I think I'm doing a lot better… I'm just like getting better levels and so I'm concentrating more, I want to start revising more, try and move back up to set two.
>
> (Danielle, female, year 9)

Danielle succeeded in her endeavours, so by the time she was interviewed in year 11 she had worked her way up to the top set in science:

> Danielle - I think the fact I'm in set 1 and everyone around me is predicted A*s and I'm predicted a C is a bit daunting, but if I get my science results and I get a C I'm not going to be ashamed of it. I'm not going to be embarrassed. I'm not going to be upset because I'm still going to be proud that I passed, so I'm not bothered about what it says as long as it's higher than a C, C or higher.

> I - So why are you in that set if …?
>
> Danielle - Um, because I was too good for set 2 and they just never changed my – apparently my predicted level is now a B, but it's not. It's still a C on like records and stuff.
>
> <div align="right">(Danielle, female, year 11)</div>

Danielle had been moved by her school up to the top set of science because she was 'too good for set 2', however the above quote suggests she still did not believe she belonged there. Her lack of confidence in her academic ability had existed since primary school, when she described herself as a 'middling' student in school in her year 6 interview ("I'm in the middle table for everything"). Unlike Stahl's (2016) White working-class boys who aimed to be academically average, Danielle hoped to get 'higher than a C' and was predicted to get a B. Nevertheless, Danielle did not appear to believe this new predicted grade and claimed that she would not be embarrassed with her grades in science as long as she passed.

Danielle's fluctuating academic identity is more revealing when contextualised against her interpretation of what a 'good' student was:

> I - Would you say that generally you're a good student or kind of in the middle or …?
>
> Danielle - Middle.
>
> I - Middle, why do you say that?
>
> Danielle - Because I talk a lot. I'm very talkative.
>
> <div align="right">(Danielle, female, year 6)</div>

Danielle, like many of her female peers, initially interpreted the question of whether she was 'a good student' as an enquiry of her behaviour, rather than of her attainment, recalling a discourse of 'behavioural compliance' (L. Archer et al., 2017). The findings are similar to Archer et al.'s (2007b) study of working-class girls' engagement with schooling, which found for working-class girls, compliance to gendered and classed educational (and social) norms was required in addition to maintaining high attainment in order to be considered a 'good student'. Her perception of the association between being 'good' and 'good at science' is further supported by the testimony of her mother, who described Danielle as being top in

science at her primary school but often excluded from enrichment activities because of her chatty nature:

> There was four particular children in school, and every time there was a trip or something these four particular children were chosen every time. And they did a science trip to the Science Museum and she didn't even get picked for that, and yet she was the top in her class for science... and they said it's well ... it's because of her behaviour... (Danielle)'s very chatty... That does hold her back a bit really. But her ability I think is quite good, it's just that the talking holds her back.
>
> <div align="right">(Sandra, Danielle's mother, year 9)</div>

Indeed, Danielle had been disciplined by her school for being too chatty even when she was known to be talking about the topic at hand:

> She sort of acted like the class clown. And I think that's backfired against her, because then the teachers don't take her seriously. And she talks – she's always been a talker, she's always been in trouble... they put her on report, she's been on report so many times... I think it was the History teacher, he said 'She's not talking about last night's *EastEnders* or something, she's actually talking about the subject' he said, 'but it's distracting'.
>
> <div align="right">(Sandra, Danielle's mother, year 11)</div>

The multiple instances of Danielle's school disciplining her for being too talkative illustrate the pedagogic work school institutions will engage in to communicate how they believe a 'good student' should behave, particularly female students. This recalls historical 'civilising' discourses acting on women, where they are expected to perform a docile version of femininity (Skeggs, 1997). In the science classroom, this is translated as girls being expected to achieve high attainment through diligence and hard work, yet they are unlikely to be identified as having a 'natural talent' for science, while the opposite is often true for boys (Carlone, 2004). As Archer, Moote et al. (2016a) found in the wider ASPIRES study, the female participants who were able to construct an 'intelligible science identity' in physics were those who positioned themselves as 'exceptional' from 'normal' girls. These students were not from White working-class backgrounds, and largely rejected the popular heterofemininity performed by girls like Danielle. Thus, despite Sandra's description of Danielle as the 'top in her class for science' while in primary school, Danielle did

not see herself as being 'good at science', and this self-perception continued into secondary school where her teachers 'did not take her seriously'.

Danielle's mother, Sandra, did not fully accept the decisions of the school as being in Danielle's best interests, although as was often the case in this study, did not appear to challenge the school about it. In the interview, she questioned why they had put Danielle in the lowest set for science when she started secondary school and postulated a connection between this decision and Danielle's strained relationship with her primary school teacher, rather than her academic ability:

> When she started at (secondary school) she was put in the lowest set (for science)… That was her best subject (at primary school) and she was top in her science class. *It was quite a shame*… (They put her in the set) just going on recommendations from her primary school. *I think it was a bit personal really*.
>
> (Sandra, Danielle's mother, year 11, emphasis added)

According to Sandra, Danielle's behaviour had led her to be (unfairly) excluded from science enrichment organised by the school, and now the top science sets where she felt Danielle belonged (and eventually worked up to). Interviews with both Danielle and her mother, Sandra, suggest her placement in the lowest set for science had a direct impact on her enthusiasm for the subject:

> I was talking to her about it and she said that's put her down a bit. It made her less interested (in science) because she felt like she didn't expect to achieve much.
>
> (Sandra, Danielle's mother, year 11)

> I've always liked science, because… I find it fun. The only thing is now I used to feel really good at science at my old school because no one else was that good at science and now I feel like I'm not quite as good, because everyone else is better.
>
> (Danielle, female, year 11)

The above quotes suggest that Danielle's position in the bottom science set of science affected her self-confidence in the subject, echoing similar findings in studies on student grouping. Francis, Connolly et al. (2017) found students correlated set placement with fixed ability, rather than current attainment, and therefore being placed in the lower sets signalled to the students a lack of ability in that subject. They

also argued that set placement (usually based on prior attainment) reflected a range of societal factors, adding that students from lower socioeconomic groups were over-represented in the lowest sets (Francis, Archer et al., 2017). In placing Danielle at the bottom of the science hierarchy, it is suggested that her school used pedagogic action to communicate to Danielle that she did not have the ability to achieve in science. This was recognised by her mother, Sandra, but she did not challenge it, once again reproducing the White British working-class habitus of 'watchful and concerned' but, ultimately, 'letting things be'. As a result, Danielle felt she 'not good enough' to do Triple Science.

Danielle, along with Bobster, had been one of the most constant science enthusiasts in this study. However, as a White British working-class female she faced similar obstacles to Lucy and Celina, as well as additional pedagogic work undertaken by her school, in navigating her way to educational success in science. Danielle's exclusion from science enrichment due to her 'inappropriate' behaviour in school and her (questionable) placement in the lowest science set at the beginning of secondary school meant that despite the considerable effort she put in to move up from the bottom to top set in science, Danielle had internalised the idea that she was not the right kind of student to do Triple Science. Indeed, it is possible that the hard work Danielle had undertaken to get to the top set of science only served to demonstrate to her that academic success in science did not come easily to her, thus reproducing the gendered discourses of the 'good science student'.

When talking about science in general and whether she aspired to study science beyond her GCSEs, Danielle was more hopeful. Nevertheless, Danielle was acutely aware that access to doing her favourite science subject at A Level was dependent on her GCSE grades:

> I was going to take Physics (A Level), but I've got to wait and get my results from my exams back, because if I don't get a B I can't do Physics."
>
> (Danielle, female, year 11)

Ultimately, as reported in the previous chapter, Danielle decided to self-exclude from Physics A Level, despite being given the opportunity to do it on a probationary basis. While demonstrating considerable agency through her negotiations with her teacher,

the compromise offered of access to Physics on a trial basis appeared to, once again, communicate to Danielle that she was unlikely to be academically successful in science. Instead Danielle opted for subjects in which she considered herself as less likely to fail, indicating dispositions congruent with the WBWC habitus of 'not rising above one's station'.

The interviews discussed above have described how most WBWC students from the study were channelled into Double Science by a number of factors including lack of self-confidence in academic ability, restricted access to the more prestigious Triple Science and a desire to do 'the same as everyone else'; while a small minority were socialised by their experiences in primary and secondary school to welcome the opportunity to take the 'elite' Triple pathway. The next section explores the year 11 cohort survey to observe the patterns occurring in the interviews appear in the wider student cohort and how they compare to students from other sociocultural backgrounds. This is followed by a broader discussion of what the interview and survey findings indicate regarding the relationship between the GCSE science pathway a WBWC student takes and their post-16 science choices.

7.4. Findings from the year 11 ASPIRES surveys

Drawing again from the ASPIRES year 11 survey (*N*=13,410) this section explores the responses related to student uptake of Double vs. Triple Science, in order to contextualise findings from the interviews. The year 11 ASPIRES survey asked respondents which science award they were pursuing at GCSE. Respondents were given the options: *Double Science*, *Triple Science*, *Applied Science*, *Some Other Science (e.g. BTEC)* and *I Don't Know*. This section explores wider patterns of Double Science vs. Triple Science uptake, in particular whether WBWC students are more likely to take Double Science than Triple Science and whether there were any notable trends related to gender (F/M), race (WB/ME) or class (WC/MC). Table 7.1. shows the percentages of respondents who responded that they took *Double Science*, *Triple Science*, *Other* (a composite of *Applied Science* and *Some Other Science*, due to the small numbers of responses) and *I Don't Know*. As noted previously, there are limitations to this data, including the Minority Ethnic variable, which is a composite and therefore does not differentiate between Black students and South Asian

students. Nevertheless, the survey data still provide a useful depiction of wider patterns of WBWC students' uptake of GCSE science pathways.

Table 7.1: Percentage of year 11 students reporting taking GCSE Science Awards

| Survey | Sociocultural group | | | | | | | |
| | WBWC | | WBMC | | MEWC | | MEMC | |
	F	M	F	M	F	M	F	M
Double	41.1	40.7	38.8	35.4	32.5	39.0	33.5	34.2
Triple	30.1	31.3	47.6	51.5	51.1	39.5	57.2	54.2
Other	18.2	16.9	8.8	7.6	12.0	11.3	5.6	6.1
Don't Know	10.3	11.1	4.8	5.6	4.4	10.2	3.6	5.6

Table 7.1. shows that similar percentages of male and female respondents report taking Triple Science, except in the case of the MEWC respondents, where noticeably more female respondents reported taking Triple than their male peers. Otherwise, a trend appears with WBWC being noticeably less likely to report taking Triple Science than respondents from other sociocultural backgrounds – less than a third of WBWC respondents, compared to around a half of WBMC and ME respondents (except MEWC males who were positioned mid-way between the two at 39.5%). There was also a trend for WBWC respondents to be far more likely to report taking Double Science or one of the 'other' GCSE science awards than any other sociocultural group. These findings suggest that WBWC respondents are located at the intersection of classed and racialised differences in which science award they take, in that they are proportionally less likely than most other groups (except, perhaps MEWC males) to take the Triple Science award compared to Double Science.

These findings suggest that the classed and racialised patterns found in the interview data, with most WBWC students being channelled away from Triple Science, are also observable in the wider context, and that MEWC males may also be subject to the same restrictions. The similar response for WBWC male and female respondents is interesting, although the interviews suggest that for these students, a gender effect is more apparent in the reasons WBWC students give for choosing Double Science,

rather than choosing between the two science pathways. Together, these findings help to respond to the third research question, which is concerned with the mechanisms influencing WBWC students' choice between Double Science or Triple Science pathways. The second part of that question asked what ways WBWC students' GCSE science choice affected their ongoing science participation, and this will be explored in the next section.

7.5. The relationship between GCSE science pathway and WBWC students' ongoing science participation

Chapter Two showed that choice of Triple Science has been found to be the strongest determinant of ongoing science participation, and it is arguable that it was a fairly reliable indicator in this study. Chapter Six has already reported that only two of the WBWC students in the interview study chose to continue with science subjects at A Level, Football Master and, initially, LemonOnion. Both of these students successfully completed the Triple Science award. The findings from the interview study demonstrate that the WBWC values of egalitarianism and of not rising above one's station – the opposite of the exceptionalism and entitlement evidenced in middle-class (particularly male) practices – interact with WBWC students' disadvantaged position within the (middle-class) school science field to disproportionately filter these students into the less prestigious Double Science route.

This chapter has discussed the case of Danielle - a student who took Double Science and wanted to take Physics at A Level but was offered only probationary access based on her attainment at GCSE and eventually decided to self-exclude. However, this restricted access was not universal to all subjects, and Danielle eventually took a number of subjects at A Levels which she had not taken at all at GCSE. Meanwhile, the few WBWC students taking Triple Science appeared to take it for granted that they would have access to science A Levels and did not mention grade requirements. The chapter has also presented evidence that the WBWC students who chose Double Science appeared not to be informed by their teachers of the exchange-value of Triple Science i.e. that it is generally considered to be the most appropriate pathway for ongoing science participation (*see* Chapter Two). These findings suggest that

science A Levels are more protected than other subjects and reveal schools' biases against Double Science for future science participation.

Furthermore, it is arguable that similar discourses surrounding Triple Science and science A Levels i.e. highly academic, difficult, prestigious and 'gold standard' gateway qualification to ongoing science participation (L. Archer, Moote et al., 2016b; Homer, Ryder et al., 2014; Smith, 2011a) indicate that the factors diverting WBWC students away from Triple Science equally deflect them from science A Levels. The students in this study expressed dispositions which indicated an aversion to risk in their subject and qualification choices as well as values such as 'being no better than anyone else', the inherent usefulness of a qualification rather than its exchange-value and trusting (or at least, not challenging) the judgement of teachers. It is argued that these dispositions can equally be applied to their position on science A Levels. If taking a science subject at A Level is not a usual route for students 'like them', this makes WBWC students less likely to consider science A Levels as a viable option. This not only reproduces WBWC under-representation in this field, but the classed, racialised and gendered nature of who can be (academically) successful in science.

7.6. Summary

This chapter discussed the discourses used by participants regarding their choice of the Double or Triple Science route, reflecting on the implications of this decision for students' participation in science A Levels. Most participants were channelled into Double Science and the chapter began with an exploration of the discourses used by these WBWC students to justify this placement. Student rationale largely fell into two camps, although there was some overlap, with the two camps representing gendered discourses which positioned Double Science as either the 'standard' option for students like them and a qualification with sufficient *use-value* for their future needs, or more 'achievable' than Triple Science. The former rationale was that used by all male participants who chose (or were automatically selected into) Double Science, and some female participants. It was observed that a number of these students appeared to have the ability to do Triple Science, yet structural restrictions within their schools turned the choice of Triple Science into a sacrifice of one of their other GCSE subject options, a choice they deemed to be not worthwhile.

The rationale of Double Science being more 'achievable' was used by a number of the female students, again despite appearing to have the ability in science to normally be selected for the Triple Award. These participants did not tend to mention structural obstacles to the choice of Triple Science, but rather did not deem themselves to be academically capable of taking that route. Students who chose to take Double Science reported they largely made their decision by themselves (although there was some evidence of being guided by their school), and their parents' lack of certainty regarding which route their child was on suggested they were happy to let students follow their own path. The findings suggested schools serving White British working-class students can undertake various forms of pedagogic work which result in the production of discourses that Double Science was the most appropriate option for students 'like them', regardless of ability in science.

The second half of the chapter began with an exploration of the rationales used by a minority of participants who chose to do Triple Science. Analysis of their previous interviews demonstrated that they had been socialised by their primary and secondary schools to feel comfortable occupying the 'top' positions in school and therefore had an easy transition into the more prestigious Triple Science route. All of these students reproduced discourses that Triple Science was an elite subject for the 'brightest' students, although the extent to which they aligned themselves with this discourse varied, with the male participants more easily accepting their place in Triple Science that their female peer. The remainder of the chapter discussed the experiences of two students who had held aspirations to study science at A Level and the impact on these aspirations of their school's pedagogic action to preserve Triple Science for 'good' science students. It was argued that the male participant suffered from a destabilised habitus as a result of being socialised by his school to aspire to be at the top, but then dropped to Double Science when his attainment wasn't sustained while the female participant was placed in the bottom set for science so she wasn't deemed eligible for Triple Science, despite working herself up to the top set in her final year. Neither student deemed themselves to be academically capable of doing science at A Level as a result.

The chapter concluded that the discourses used by students, and their parents, not only reflected the differential pedagogic work undertaken by schools serving White British working-class communities, but also the classed, gendered, racialised nature of who is considered able to be academically successful in science. The implication is that one cannot maintain a White British working-class habitus and take the most prestigious science pathways. As Triple Science is considered to be the main gateway to science A Levels, and science A Levels are considered the 'gold standard' qualification for science study at university, this has significant consequences for addressing social inequalities in post-16 science participation. The next and final chapter of this thesis draws together the findings and the contributions of this study and includes a fuller discussion of the limitations and implications of this research as well as possible directions for future research.

8. Discussion and Conclusions

8.1. Introduction

The research conducted as part of this thesis sought to shed light on why students from White British working-class (WBWC) backgrounds do not tend to continue with science once it ceases to be a compulsory subject, in response to evidence that WBWC students are under-represented in science pathways beyond GCSE (*see* Chapter One). Prior research investigating post-16 science participation has tended to focus on individual-level student factors such as attitudes towards science and prior attainment, and investigated the effects of gender, ethnicity or socioeconomic status on a discrete basis (e.g. Gorard & See, 2009; Homer, Ryder et al., 2011). More recently there have been calls for new research to investigate the social, cultural and structural factors causing disadvantaged groups to navigate away from science (Claussen & Osborne, 2012), a call taken up by the ASPIRES project (see L. Archer, DeWitt, Osborne et al., 2013). As of yet, however, there has been little, if any, research focussing on WBWC students' experiences in school science. This thesis makes an empirical contribution to knowledge by improving understanding of why and how WBWC students, both male and female, are under-represented in science at A Level.

Using a sociocultural approach informed by Pierre Bourdieu's theories of social reproduction in education and operating within the critical realist paradigm, this thesis investigated WBWC students' experiences in science at primary and early secondary to identify potential mechanisms which generate the tendency not to continue studying science at A Level. Reporting on semi-structured interviews with WBWC students (*N*=12) and their parents (*N*=12), and with access to longitudinal interview and survey data provided by the ASPIRES study (*see* Chapter Four), the thesis addressed three research questions. First, it described the long-term nature of WBWC youth engagement in out-of-school science, then it explored the relationship between out-of-school science engagement and WBWC students' participation in science A Levels, given that extra-curricular science has been frequently cited as an

important factor in science participation more generally (Dawson, 2014; Gokpinar & Reiss, 2016; Stocklmayer, Rennie et al., 2010). The third research question concerned identifying possible factors influencing WBWC students' choice between Double Science or Triple Science pathways, following evidence that students taking Triple Science are more likely to continue science study at A Level (National Audit Office, 2010). Data were analysed using a framework incorporating Bourdieu's concepts of habitus, capital and field (Bourdieu, 1985a), with a particular focus on the intersection of gender, social class and ethnicity (*see* Chapter Four), to improve understanding of why WBWC students do not tend to participate in science at A Level.

The findings of this study improve our understanding of the mechanisms generating WBWC tendency towards non-participation in post-compulsory science in two ways: firstly it provides a non-deficit explanation of WBWC students and their parents' minimal engagement with science in both in-school and out-of-school contexts; secondly it presents an intersectional analysis of how values and structures constituting the field of school science are in tension with a number of key WBWC dispositions.

This final discussion chapter draws together the analyses across the three results chapters and incorporates key literature foreshadowed in the review chapters to discuss the main findings and contributions of this thesis in the wider context of WBWC students' engagement with school science education. The chapter is in two parts: the first is a summary and discussion of the main research findings, framed in response to the research questions outlined above (and discussed more fully in Chapter Two). The chapter concludes with a discussion of the limitations and implications of the study, and thoughts for further research.

8.2. Main findings and contributions to knowledge

This thesis explores new territory in post-compulsory science participation research by investigating the science engagement of White British working-class students – a group historically under-represented in post-16 science. It extends existing work by researchers who have used Pierre Bourdieu's theories of social reproduction to

explore WBWC engagement in education more generally (e.g. Ingram, 2011; Reay, Hollingworth et al., 2007; Stahl, 2016), those who have applied a Bourdieusian lens to the field of science education (e.g. Adamuti Trache & Andres, 2008; L. Archer, Dawson et al., 2015; Claussen & Osborne, 2012; Lyons, 2006; Wong, 2012) and intersectional approaches to the construction of 'legitimate' forms of scientific knowledge (e.g. Collins, 1999; Luttrell, 1989).

The study reported on in this thesis involved an in-depth analysis of the out-of-school science engagement of twelve WBWC students situated in deprived rural and urban neighbourhoods around England. The data analysed were taken from interviews with the students (and, separately, their parents) at four points in their school education; beginning in 2010, when students were in the last year of primary school, and ending in 2016, the last year of science as a compulsory subject in secondary school. This was followed by an analysis of the students' in-school experiences with the structure of Double and Triple Science Award pathways. The findings in this thesis provide empirical data that challenge deficit discourses surrounding the White British working-classes and their participation in science, demonstrating that many WBWC students actively engage in out-of-school science associated with canonical science i.e. scientific knowledge and/or skills recognisable in the science classroom (*see* Chapter Two), at some point in their compulsory education, and many also have the attainment to continue their studies in science once it ceases to be a compulsory subject. The study also found the (so-called) student choice between the Double and Triple Science streams served to construct a field where success in science was considered incompatible with expressions of the traditional White British working-class habitus.

This section takes a more detailed look at the main findings of the study, reflecting on the out-of-school and in-school science experiences of WBWC youth in the context of the research questions posed above, and discussing what this means for their continued participation in science. The section begins with a discussion of the findings regarding WBWC students' experiences of out-of-school science.

8.2.1. How do WBWC youth experience and think about science out-of-school?

As discussed in Chapter Two, little is known about the extent and nature of White British working-class youth engagement in science in out-of-school contexts, despite claims such activities are positively associated with science participation. In recognition of the gap in knowledge this presented, and the availability of both longitudinal qualitative data and large quantitative data sets, this thesis dedicated Chapters Five and Six to findings related to the ways White British working-class students engaged in science in out-of-school contexts, and how this changed over time.

The interview data included (separate) accounts from both students and their parents, allowing for an additional discussion of WBWC parental involvement in their child's engagement with science, as well as occasionally providing further detail of the nature of activities undertaken (*see also* Chapter Three). The main findings from the student and parent interviews, and the contextual findings from the surveys, are discussed further below, beginning with student engagement in primary school.

8.2.1.1. The nature of early WBWC out-of-school science engagement

As outlined in Chapter Five, when participants were interviewed in primary school they reported wide and varied engagement in out-of-school science activities, many of which were relatable to canonical science. Indeed, at this time students almost universally spoke of science in positive terms, although engagement tended to be self-led rather than involve their parents or other family members (*see* sub-section 8.2.1.3). Survey data from the same period showed small gendered and classed differences in *regular engagement* in out-of-school science activities, although Minority Ethnic students reported more regular engagement in all science-related activities compared to their White British counterparts – particularly related to science media, such as reading science books or watching science TV programmes. However, classed differences did appear in the data reporting responses of *minimal engagement* in out-of-school science, while the race differences shrank. Overall, the findings from the interview and survey data suggest that in their early years, White British working-class participants engaged in a spectrum of out-of-school science

engagement activities comparable to peers from other sociocultural backgrounds. However, the tendency towards self-led leisure time indicates that, overall, WBWC students were less likely to engage in out-of-school science activities than their peers from middle-class backgrounds.

While the ASPIRES survey data allowed for broader comparison of the regularity and type of engagement in out-of-school science activities between students from different sociocultural backgrounds, the interview data afforded an opportunity to look at the nature of the activities in far greater detail. Through taking a Bourdieusian approach to this analysis, a typology was developed based on how strongly activities were associated with dominant science-related cultural capital (defined as scientific knowledge and skills established and recognised in canonical scientific culture – *see* Table 5.1., Chapter Five).

The typology served as a helpful tool in exploring the types of science-related resources WBWC students had access to in out-of-school fields, with the aim of identifying students' science-related cultural capital with *exchange-value,* that is, resources with the potential to be leveraged in the school science field (Claussen & Osborne, 2012). The typology consisted of three types of activity: *science play*, *consuming science media* and *experiential science activities*, and was based on students' reported engagement while in primary school (*for more details and justification, see* Chapter Five)*. Science play* were activities where participants attempted to play at being a scientist but apparently without concern for including or developing dominant scientific knowledge or skills; *consuming science media* was instances of participants consuming 'cold' formal scientific knowledge through different forms of media such as books, documentaries and educational websites, but not necessarily concerned with developing and practicing dominant scientific skills; *experiential science activities* were hands-on, practical activities which clearly had connections with scientific skills and, potentially, knowledge; for example designing and implementing science projects derived from science books or replicating those done at school, or science 'kits'.

When interviewed in primary school the most common activity was science play, however most participants also reported engaging in either consuming science media

or experiential science activities, or both, while at home. In doing so, they had the opportunity to develop science-related cultural capital which could be *embodied* as "long-lasting dispositions of the mind and body" (Bourdieu, 1986, p.47), making them more familiar and comfortable with the sub-culture of science in the school environment (Aikenhead, 1996). Indeed, many of the participants expressed such dispositions in their year 6 interviews, speaking of science as holding a 'special place for them' e.g. Danielle, Bobster and Hedgehog (*see* Chapter Five). Some of these students were actively supported in their engagement by parents who invested time and resources to foster their child's interest in science (*see also* section 8.2.1.3). Overall, these findings are evidence of active early engagement on the part of many WBWC students to develop dominant cultural capital related to science, challenging discourses which position the White British working-classes as suffering from a cultural deficit (The Runnymede Trust, 2009). It is argued that many of the WBWC students in the study had begun to develop a scientific habitus – one that was 'at home' in science – and it was therefore expected they would be likely to continue actively engaging in out-of-science as they transitioned from primary to secondary school.

8.2.1.2. WBWC out-of-school science engagement in secondary school

Chapter Six showed that engagement in out-of-school science for the majority of students dropped away in secondary school (aside from occasionally watching science TV programmes), as they considered themselves to be 'too grown up' for such activities. This was true for students who had only engaged in *science play* but also for students who had engaged in the *experiential science activities* such as science kits and projects outside of school (*see above and* Chapter Six). This diversion away from out-of-school science coincided with students' expression of dispositions which were increasingly classed, racialised and gendered. This was argued to cause students a 'habitus tug' as they found the middle-class field of science positioned in opposition to the WBWC field of home. In order to resolve this tug, many WBWC students kept their engagement in science reserved for the school science field and removed it from the field of home almost completely.

The few students who reported continuing to have an interest in engaging in science out-of-school had mixed success in doing so, largely dependent on access to their school-based science/STEM club (*see* Chapter Six, section 6.2.2). Two female students recounted being aware of the existence of a school-science club but self-excluded: Danielle felt that as a girl she was in the minority and that she didn't belong, Celina because she hadn't enjoyed school science at the time. Data from the ASPIRES survey showed that White British working-class girls were particularly under-represented in their school science/STEM club, suggesting that the female participants discussed above were not alone in thinking that a school-science club was 'not for them'. The findings emphasise the acute nature of WBWC adolescent females' limited access to age-appropriate out-of-school science activities, even when accounting for their interest in science.

Two male participants who had previously engaged in experiential science activities at home, MacTavish and Dave, reported they did not attend their lunchtime school science club as it conflicted with their football practice (an activity traditionally associated with White British working-class masculinity). Thus, the only participants who continued to engage in out-of-school science at secondary school were two male students who regularly attended their school science/STEM club, which they constructed as exclusive and prestigious and reported feeling comfortable in such an environment. Football Master and Bobster were also the only participants who considered themselves as 'science people' and demonstrated enduring science-related, academic dispositions throughout this later period. These findings support other research looking at the importance of science clubs for generating positive attitudes towards, and aspirations in, science (Dabney, Tai et al., 2012). Membership to these science/STEM clubs provided an opportunity for these two students to have ongoing exposure to dominant science-related cultural capital, and to feel entitled to similar forms of capital in other fields. Being school-organised, it is argued the structured, school-like activities were likely to transmit cultural capital recognised as having exchange-value in the school field more widely. This placed the two male students who attended the club on a long-term basis in an advantageous position; the science-related cultural capital they acquired could potentially be leveraged in

the science classroom in exchange for academic achievement as well as increased status amongst their science teachers.

Nevertheless, the findings also provide evidence that such enrichment activities on the whole do not tend to attract or retain WBWC students, even when they have expressed prior interest in science. Instead, they were constructed by WBWC youth as for a certain kind of student, one that embodied masculine and non-practical (i.e. academic) dispositions; a revealing and disheartening finding considering the aim of such initiatives to give students practical and hands-on experiences in science (STEM Learning, 2018). Any benefits derived from such engagement (from visits to universities and external speakers to the conversion of obtained cultural capital into educational success – *see* Chapter Six), were then preserved for students who were willing and able to develop such dispositions. The findings build on existing studies which have found female students experiencing a tension between their gendered identities and a viable science identity (Calabrese Barton, Tan et al., 2008) and extend Ingram's (2011) work on male White working-class students' difficulties in reconciling their identity with academic success. This thesis has demonstrated only a minority of (male) WBWC students were successful in developing and sustaining the required dispositions which enabled their habitus to feel at home in their school science/STEM club, at the expense of dispositions more commonly associated with White working-class culture. Thus, most WBWC students in the study, particularly WBWC female students, constructed the idea that in later years, out-of-school science was 'not for students like them'.

8.2.1.3. The role of parents in WBWC students' out-of-school science engagement

Chapter Five discussed interviews with parents while their children were in primary school, revealing that several of them were also invested in their child's out-of-school science engagement at this age. A number of the students who took part in experiential science activities were directly supported by their parents who purchased books, kits and, in one case, involved in organising a trip for their child to visit NASA in Florida. Other parents were less active, but nevertheless supportive of their child's interest in science. In these cases, student engagement tended to be self-led rather than parent-led. This echoed findings from Lareau's (2011) study of classed

approaches to child-rearing, where working-class parents were more likely to allow their child the freedom to independently 'accomplish natural growth', while middle-class parents were more involved in their children's leisure time and tended to plan activities which would cultivate their child's natural talents and expose them to dominant cultural capital.

Nevertheless, the actions of the more involved WBWC parents in this thesis suggest that Lareau's differing approaches to child-rearing may not always be class-specific, as Siraj Blatchford (2010) found in her study of the concerted cultivation undertaken by working-class parents. Indeed, they may be dependent on whether parents' have the cultural capital to appreciate the potential benefits of out-of-school enrichment. Bourdieu argued the importance of the family in the transmission of cultural capital (Bourdieu, 1986) and *family education* is considered by many to be the greatest source of embodied cultural capital (Claussen & Osborne, 2012). In the case of science, this would be parents knowing the potential exchange-value of science in different social fields and providing their children with opportunities for acquiring the science-related cultural capital recognised in those fields (Adamuti Trache & Andres, 2008; Lyons, 2006).

The 'active' parents discussed above showed evidence of this knowledge through encouraging their children to do the 'right kinds' of activities in their spare time at an early age e.g. Bobster doing Scouts and Danielle doing 'extra homework' at home. This is argued to be proof that the family education of students from (White) working-class backgrounds can be a sufficient source of embodied science-related cultural capital, and that WBWC parents also engage in the processes of converting forms of capital into educational success in science. Yet the evidence of a significant number of parents who were more passive in supporting their child's interest in science (e.g. Dave's mother, Jane2 and Charlie's mother, Robyn) suggests that this claim may not be generalisable to the same extent as students from other sociocultural, particularly middle-class, backgrounds (L. Archer, DeWitt et al., 2012b). Nevertheless, these findings problematise pathologising discourses which position White working-class parents as disinterested in their children's development (Gewirtz, 2001; Stahl, 2016),

instead demonstrating that WBWC parents tend to be less strategic about their children's leisure time.

As the participants grew older, their parents became noticeably less involved in their children's extra-curricular engagement. Chapter Six showed how many of them, even the ones who had been noted as active in earlier years, didn't feel that they could push their children towards particular activities because as teenagers they were allowed to have greater autonomy over their spare time. Data from the year 8, year 9 and year 11 surveys suggested that similar patterns occurred over the wider student cohorts. The findings show that WBWC families who were actively engaged in acts of 'concerted cultivation' tend did so when their child was younger, but as they grew older the parental approach became more passive, in line with other working-class families. This raises questions about the sustainability of concerted cultivation by WBWC parents and highlights the need to encourage and support sustained participation in these activities in the transition between primary and secondary school.

As Bourdieu argued, in order for transmission to be most effective, exposure to cultural capital must be early *and* long-lasting (Bourdieu, 1986). The majority of the WBWC students in the thesis reported only short-term exposure to dominant science-related cultural capital, although interviews with their mothers revealed that a number of them had considerable 'hot' medical knowledge with *use-value* but did not recognise its potential *exchange-value* in fields outside the home. It is suggested that such knowledge and expertise represent the forms of science-related cultural capital potentially transmitted by WBWC parents to their children, which are nonetheless misrecognised in the science classroom.

The findings above also somewhat complicate the argument regarding the viability of the White British working-class family education as a source of embodied *science-related* cultural capital. With lower levels of dominant science-related cultural capital themselves, it is suggested the WBWC parents in the study felt better able to support and encourage their child to engage in out-of-school science while they were younger. Meanwhile, middle-class parents (who are more likely to hold dominant science-related cultural capital) are better able to weather their child's changing

requirements for more 'grown-up' out-of-school science activities, such as family discussions and debates about science-related news items and maintaining household subscriptions to science magazines geared to a more mature audience (L. Archer, DeWitt et al., 2012b). The implication is that many WBWC families are unable – or unwilling – to establish the suitable conditions to successfully transmit embodied science-related cultural capital with exchange-value to their children when they move beyond primary age. As a result, such WBWC families potentially, and unknowingly, perpetuate a cycle of the non-development of enduring science-related dispositions in their members. Furthermore, by being more passive with regards to their children's out-of-school science engagement during secondary school, these WBWC parents are withdrawing a significant source of their (symbolic) advocacy of science (Lyons, 2006). It is argued that this profoundly influences WBWC youth's ideas about being 'too grown up' for science and their subsequent construction of science as 'only for school'

This thesis has shown the complexities of WBWC students' experiences with out-of-school science. Early engagement was widespread, positive and often actively supported by their parents; however for most students this engagement was short-lived. The overall picture provided by the thesis is that as WBWC students grew older, opportunities for the continued exposure to out-of-school sources of embodied science-related cultural capital were limited. School science/STEM clubs have the potential to fill this gap, however the experiences of the students reported in this thesis demonstrated that, when they were available, they invariably failed to reflect and welcome the different values and cultural dispositions of students from WBWC backgrounds. According to Bourdieu, those who do not have the requisite capital are physically or symbolically put at a distance from the most exclusive goods and services (Bourdieu, 1999). This thesis has demonstrated that the limited out-of-school activities known to WBWC students as they reached adolescence were largely dominated by male students who had the inclination to adopt intellectual dispositions normally associated with middle-class masculinity. In other words, WBWC students, especially female WBWC students, are often symbolically (and frequently physically) distanced from one of the few viable non-family sources of

embodied science-related cultural capital available to students of secondary age. Instead of providing interested WBWC students with the opportunity to maintain and develop science dispositions outside of the science classroom, such dispositions were largely allowed to fall by the wayside. This has troubling implications for the viability of structured out-of-school science activities for widening participation in science (*see* 'Implications for research, policy and practice' section 8.5).

This thesis has argued that out-of-school science engagement is important for increasing interest in science and providing opportunities for WBWC students to have access to science-related cultural capital which can become embodied. Nevertheless, it is contended that the school field can substantially amplify or trump its effects on post-16 science aspirations, depending on how closely individuals subscribe to WBWC norms and values. These findings challenge the strength of arguments that children spend the majority of their time outside school, therefore home and family influences on educational achievement are perhaps more significant than school-based ones (Association of School and College Leaders, 2013). Instead, efforts taken by WBWC students and their families to engage in science out-of-school will be unlikely to lead to ongoing science participation unless the students themselves are willing and able to align themselves with middle-class, academic dispositions. As discussed in Chapters Six and Seven, most WBWC students, especially the female students, struggled to do so – regardless of their attainment levels.

8.2.1.4. Original contributions on WBWC out-of-school science engagement

As noted previously, there is a growing body of literature which explores the practices undertaken by (White) middle-class families to develop their child's engagement in science within out-of-school fields, and how such engagement can form part of a strategy to support their educational achievement within in-school science fields. Yet there is minimal understanding of the nature of out-of-school science engagement of White British working-class families, despite assumptions which may arise due to wider discourses suggesting they are disadvantaged due to parental apathy or a cultural deficit (The Runnymede Trust, 2009). This thesis provides an empirical contribution through its account of the out-of-school science engagement of White British working-class youth over time, as well as the approaches taken by their

parents to support them – or not – in this engagement. Furthermore, the thesis has made a methodological contribution with the Bourdieusian-informed typology of science activities (*see* Chapter Five, section 5.2), which categorised activities based on their association with dominant science-related cultural capital or 'canonical science'. The thesis also contributes an analysis of the relationship between WBWC students' out-of-school science engagement and ongoing science participation, concluding that even in cases of regular and high-level science engagement, school-level factors can confound even the strongest-held science aspirations.

8.2.2. How do WBWC youth experience and think about science in-school?

Based on findings emerging from the data – in particular the negative impact taking the Double Science award apparently had on two of the participants who had previously held very strong science aspirations – and the strong relationship between uptake of Triple Science and ongoing science participation highlighted in the literature, Chapter Seven discussed White British working-class participants' navigation of the choice between the Double and Triple Science awards. Interviews with participants showed that most of them took Double Science, rather than Triple Science. These findings were in line with survey data from the ASPIRES study, which showed that WBWC students were far less likely to take Triple Science than students from other sociocultural backgrounds except Minority Ethnic working-class males. Taking into account the under-representation of WBWC students in post-compulsory science, one may cautiously consider these findings as supporting other studies which cite Triple Science as a strong predictor for future science participation (Education Standards Analysis Research Division, 2011). Nevertheless, it was not a simple case of students from other backgrounds being more likely to *choose* Triple Science than WBWC students. Indeed, as found in the wider ASPIRES Project (*see* L. Archer, Moote et al., 2016b), the notion of 'student choice' of Double or Triple Science was not as straightforward as it may seem.

8.2.2.1. WBWC 'choice' of Double Science - A foregone conclusion?

When discussing which science pathway they were placed in, most participants claimed that the choice to take Double or Triple Science was their own, while only

two stated their school outright made the decision. In these two cases, Millie and Hedgehog were placed in the Double Science stream and the matter was not discussed with teachers beforehand, however they were reconciled to the situation. Indeed, none of the participants reported regretting their final placement, appearing to consider the use-value of Double Science to be sufficient for their future needs. The remaining students who chose Double Science spoke of doing so either because Triple Science was not made widely available within their normal timetable (such as MacTavish, Dave and Connie) or because they felt Triple Science was 'too hard' and did not want to risk failing (such as Celina, Danielle and Lucy). For both sets of students, Double Science was constructed as the standard option for students 'like them', even though many of them appeared to have high enough attainment in science to be considered eligible for the Triple Science route (*see* Chapter Seven). These findings highlight the complexities behind why more WBWC students take the Double rather than Triple Science pathway. However, they also carry the troubling implication that the decision to take Double Science is a probable outcome for many students from WBWC backgrounds, even when accounting for attainment or prior interest in science.

The few students who took Triple Science (Bobster, Football Master and LemonOnion) did not appear to have a truly free choice to take that option but had to be offered the opportunity first by their school based on their prior attainment levels and placement in the top set for science. The opportunity to take Triple Science was something these students expressed they could not refuse: in contrast to their peers discussed above, they were aware of the exchange-value of the Triple Science qualification. The findings are further evidence of WBWC students' choice of Triple Science being dependent not just on prior attainment but also their position in the school field. If a WBWC student is in their school's top set of science at the time of the Double or Triple Science choice (and their school offers Triple Science in the first place) then they are amongst those likely to be recognised by the school as 'clever enough' to take Triple Science. As discussed in Chapter Seven it is largely the school, not the family, who provided the students with cultural capital regarding the value of Triple Science – in contrast to the more advantaged students reported in the wider

ASPIRES study (L. Archer, Moote et al., 2016b). Thus, it is contingent on the school communicating the advantages of Triple Science for WBWC students to be fully informed when they make their choice of science pathway. As such, it is argued the power of the school in such decisions is significant and, therefore, contributes towards the reproduction of WBWC students' under-representation in Triple Science.

The concept of 'choice' in education has already been the subject of criticism in other research studies, which has highlighted the bias in a marketised education system towards families (and by extension, the children) who hold the most economic, social and cultural capital i.e. those from middle-class backgrounds (e.g. Francis & Hutchings, 2013; Reay & Lucey, 2003; 2010). When making decisions about choice in education, these students/families are more likely to have greater access to higher status options (i.e. Triple Science) and will be more aware of the exchange-value of such pathways. As with WBWC students' limited access to school science/STEM clubs (*see above*), this is another example of those who lack the requisite capital being physically or symbolically put at a distance from the most exclusive goods and services (Bourdieu, 1999). In the context of this thesis, it is argued that the majority of the WBWC students were distanced from the 'exclusive' Triple Science award, either because it was not physically available to them as an option, or because *pedagogic work* (e.g. making Triple Science a GCSE option or only available to a small minority of the 'top' students in school) acted to construct it as a risky choice; something WBWC parents' were more willing to accept (*see* Chapter Seven). These findings are further evidence of the problematic nature of choice in education, particularly for students who are already disadvantaged. For the WBWC students in this thesis the choice to take Double or Triple Science was not about increased freedom, but 'constraint' (Reay & Lucey, 2003).

8.2.2.2. 'Not a good science student' - the Double Science effect?

For several students who had previously spoken very positively regarding future science aspirations, experiences of in-school science appeared to mitigate these aspirations considerably. It is argued that their placement in Double Science was a significant influence on this. For example, Danielle reported difficult relationships with her science teachers (in both primary and secondary school). Her mother Sandra

observed this had affected Danielle's self-confidence in science, despite having the attainment to work her way up to the top set of science by her last year of secondary school (in contrast to the usual stasis of set designation (Francis, Connolly et al., 2017). However, by then it was too late for Danielle to be considered for Triple Science. On the other hand, Bobster had reported previously enjoying excellent relationships with his science teachers and was initially placed in the Triple Science route. However, when his attainment dropped, Bobster was moved into the Double Science stream and this seemed to significantly affect his confidence in science and his attitude toward his teacher. His mother, Martha, noted that he appeared to have 'given up' on his academic work in general after that point.

Both students no longer considered themselves as good at science, but while Bobster's interpretation appeared to be (mostly) related to his teacher's response to his change in attainment, Danielle's was also significantly influenced by how her teachers responded to her 'loud' behaviour in class. Danielle's additional concerns reflect the gendered (and racialised and classed) discourses around what it means to be a 'good student' (Hartman, 2006; Ingram, 2011; Stahl, 2016). In the thesis, the schools' handling of these students was interpreted as additional examples of pedagogic work which acts to normalise arbitrary rules regarding how students should behave in the science classroom. The science teachers' recognition of academic dispositions (associated with the middle classes) and 'misrecognition' of expressions of White working-class habitus (e.g. the 'loud' glamour of Danielle) were presented as examples of symbolic violence (L. Archer, Moote et al., 2016b; Bourdieu & Passeron, 2000; Ingram, 2009). Indeed, it is argued the use of dual science pathways enabled schools to take the processes of recognition and misrecognition further still. Limiting access to the Triple Science route made it more distinguished and thereby enabled schools to recognise the 'top' (i.e. most receptive) WBWC students. The processes of misrecognition, meanwhile, led to the more resistant (but still high-attaining) WBWC students to be placed, normally through self-selection, into the less prestigious Double Science option. These findings suggest that White British working-class students can be particularly vulnerable to pedagogic work which positions them as 'not good science students'.

8.2.2.3. Original contributions on WBWC in-school science engagement

Student uptake of the Triple Science GCSE award is perhaps the most frequently cited factor associated with ongoing science participation in the United Kingdom, although this uptake is usually predicated on prior attainment and access to the award (*see* Chapter Two, section 2.3). As of yet, there has been little exploration of White British working-class uptake of Triple Science although the frequently-used deficit discourses of a 'poverty of aspirations' and poor attainment usually associated with this group (Siraj Blatchford, 2010) suggests that take-up would be low. This thesis has contributed a picture of WBWC uptake of Double or Triple Science and an analysis of the wider context within which their allocation to one or the other took place. In particular, the thesis has demonstrated how the practice of WBWC parents allowing their children the independence to make their own decisions about their leisure time was also present in their approach to the educational choices which shape their child's future.

Furthermore, this thesis provides an improved understanding of how a number of WBWC values and practices are in tension with those operated within the science classroom – an additional challenge to deficit perspectives of this group. It provides a theoretical contribution in its development of the concepts use-value and exchange-value to explore how (largely middle-class) families can facilitate the ongoing science participation of their child through the conversion of forms of capital (economic, social and cultural) into symbolic science-related cultural capital such as science qualifications and employment. Such conversions are invisible and White British working-class parents are argued to be largely unaware of both the process and the potential exchange-value of different forms of capital. Consequently, WBWC students can be subject to significant symbolic violence in the field of school science.

8.2.3. Why do WBWC students tend not to continue studying science at A Level?

Using the critical realist process of retroduction, this research sought to investigate what the features of WBWC out-of-school science engagement and navigation of Double and Triple Science GCSE pathways reveal about the underlying mechanisms which generate the underrepresentation of WBWC students in science A Levels. It is

theorised that the mechanisms reflect multiple intersecting inequalities within formal science fields, resulting in WBWC students tending to feel that ongoing science participation at A Level is 'not for them'. This section discusses these theories in greater detail.

8.2.3.1. 'Egalitarianism' over 'exceptionalism'

As discussed in Chapter Two, science is often seen as a field reserved for the 'best' and enjoys its own, unique culture (Aikenhead, 1996; Claussen & Osborne, 2012). The special status science has in society can be seen in the ongoing tensions regarding the aims of science education: science literacy for all or literacy specifically for future scientists (Millar & Osborne, 1998; D. A. Roberts, 2007). Indeed, it is arguable that no other school subject enjoys such attention or concern regarding increasing participation. Acknowledging and redressing the elite nature of the field of science is essential to further understand how this interplays with forms of capital and habitus to result in the under-representation of White British working-class students in post-16 science fields. Furthermore, it is important to recognise that this elite status has been carefully constructed and continues to be protected by those 'within the fold' (Brooks, 2012).

Bourdieu proposed that the formal education system acts to legitimise the values and positions of certain groups through *pedagogic agencies* and their structures, claiming that these values were, in fact, arbitrary (Bourdieu & Passeron, 2000). In the context of this study, it is argued that those who wish to preserve the primacy of science are able to do so through the existence of (and managed accessed to) the 'higher level' Triple Science pathway and the alignment of membership to the school/STEM science club with the top set of science. Chapters Six and Seven discussed how such structures served to reproduce the power relations in science within school and without, perpetuating the elite, abstract nature of science and subsequently deterring many White British working-class students from choosing Triple Science or attending their school science/STEM club.

The rippling effect of these decisions on future science participation is considerable, as Triple Science is considered by many to be the natural stepping stone to science A

Levels (*see* Chapter Two) while attendance of the school science/STEM club contributes towards a habitus 'at home in science' (*see below*). This thesis argued that the discourses used by WBWC students in relation to the Double Science vs. Triple Science pathways and their school science/STEM clubs demonstrated the reproduction of 'exceptionalism' associated with science which were suggested to be in direct tension with traditional 'egalitarian' performances of the White British working-classes as per Stahl's (2016) study on White British working-class boys and, additionally, performances of White working-class femininity (L. Archer, Halsall et al., 2007a). The thesis found most male students (and some female students) distanced themselves from the Triple Science route and their school science/STEM club because they 'weren't normal practices' for students like them, while the remaining female students considered themselves 'not clever enough' to take part.

It is arguable that attainment remains an obstacle for White British working-class students continuing with science (*see* Chapter Two). Many of the cases discussed in this thesis were not in the 'top set' of science in their school, aligning with studies which see students from low social class backgrounds overrepresented in low attainment groups (L. Archer, Moote et al., 2016b; Francis, Connolly et al., 2017; Jackson, 2003). Nevertheless, there is significant evidence that set placement is not indicative of 'ability' (Taylor et al., 2017) and that being placed in lower sets not only negatively affects students' aspirations but also acts as an 'academic deterrent' (Travers, 2017). Chapter Seven explored how placement in the lower science sets led to positioning in the Double Science stream, influencing many WBWC students (particularly female students) to see science as 'not for them' and subsequently deciding not to continue with the subject (*see discussion on Danielle*, Chapter Seven). Furthermore, it is suggested that being in Double Science functioned as a further deterrent to WBWC students developing the academic dispositions required to be successful in science, more of which will be discussed below.

However, this thesis has demonstrated that even WBWC students placed in the top science sets tended not to choose Triple Science or continue with science at A Levels. The findings of this thesis provide greater detail to those from other studies which found that even when accounting for prior attainment, White working-class students

were still not taking the recognised steps (i.e. Triple Science) to continued science participation (House of Commons Education Committee, 2014). It has been argued that this is a result of the interplay between pedagogic action which works to preserve the elite nature of science, WBWC students' lack of cultural capital to recognise the exchange-value of Triple Science in post-16 markets, the cultural dispositions of the White British working-classes to aspire to 'be no better than anyone else' and 'make do', and the misrecognition of White working-classness (and performances of femininity in general) as incongruent with educational achievement. In constructing science as the preserve of 'exceptional' students, WBWC students, on the whole, dismissed it as an unsuitable path to follow.

8.2.3.2. It's more important to be studious than 'sciencey'

This research has found that the role of out-of-school science in WBWC students' future science participation is a complex one. It is argued that early engagement cannot be used as a predictor of future participation, despite the weight frequently given to out-of-school science by studies looking at the backgrounds of those who do continue in science (Maltese & Tai, 2010). Nevertheless, it is suggested that both experiential and 'cold' science activities can make a difference in providing students with opportunities to develop science-related dispositions and familiarising them with canonical scientific culture. The thesis saw that ongoing engagement in such activities enabled students to be inculcated with a scientific habitus. A small number of male WBWC students were subsequently able to leverage this and their emergent science-related cultural capital in the school science classroom for academic success and, for one participant, future participation in science. This was the exception, however, and the majority of WBWC students discussed in the thesis were not able to translate their (early) out-of-school science engagement, even in structured school-like activities, into future participation.

This thesis raises the issue of the inability of many WBWC students to convert their pre-existing scientific dispositions into future science participation as a significant concern. Researchers in science education have criticised formal science education as designed in such a way that students do not have access to sufficient opportunities to engage their critical thinking or investigatory powers (Claussen & Osborne, 2012).

Familiarity with applied scientific culture, even if based on early out-of-school engagement alone, should stand students in good stead to achieve future success in science. However, the findings of this thesis suggest a grasp of and comfort with the 'cold' abstract and conceptual i.e. academic version of science seems to be a better grounding for success in formal science. Snow (2010) discussed how many students struggle with the academic nature of scientific language, which can seem impersonal and abstract, while those who read widely have the opportunity to acquire scientific vocabulary and, perhaps, improve their comprehension in science more generally. Indeed, the only participant in this thesis who continued to study science beyond his GCSEs, Football Master, appeared to limit his early engagement in science to the consumption of science media, in particular reference books. It is suggested that his familiarity with academic, scientific language was more useful than his peers' (e.g. Danielle, MacTavish) early, out-of-school familiarity with practical scientific skills in allowing him to flourish in the science classroom and, thereby, continue with science. These findings have significant implications for WBWC students more generally, as their tendency to value and align themselves more closely with practical, hands-on forms of cultural capital (as discussed in Chapter Six) implies they are unlikely to develop the sorts of science-related dispositions which can lead them to future science participation following conventional pathways.

In their study, Ingram and Waller (Ingram & Waller, 2014) argued that notions of entitlement linked to the performance of 'inherent cleverness' enable middle-class men to access the most valuable educational experiences, and thus the most prized forms of cultural capital. The findings of this thesis suggest that science is a field where conditions are optimal for the (White) middle-class masculine habitus to perform a 'natural intellect' identity. In their 'natural' habitat of science, the performance of cerebral, middle-class masculinity leads to a sense of entitlement to the most valuable sources of embodied science-related cultural capital, for example school science/STEM clubs, Triple Science GCSE pathway and science A Levels.

These findings resonate with Bourdieu's assertion that "ability or talent is itself the product of an investment of time and cultural capital" (Bourdieu, 1986, p.48). He also argued that parental transmission of cultural capital was "the best hidden and socially

determinant educational investment" (Bourdieu, 1986, p.48). Football Master did not likely receive much dominant science-related cultural capital from his parents (*see* sub-section 8.2.1.3). However, by virtue of his gender and reflexivity to develop the appropriate (middle-class, academic) dispositions, Football Master was able to accrue substantial amounts of dominant science-related cultural capital in his interactions with various school-related science fields. Conversely, students such as Danielle who had, in earlier years, expressed an intrinsic interest in science and invested time developing her scientific dispositions, found her access to the most valuable forms of embodied science-related cultural capital offered by school-related science fields restricted, or even denied. This led to symbolic violence, as Football Master – who held the 'right' capital – internalised it as a 'natural science ability'; while Danielle – who was consistently denied the 'right' capital – came to believe herself to be devoid of talent (L. Archer, Moote et al., 2016a; Claussen & Osborne, 2012).

8.2.3.3. The suppression of WBWC scientific knowledge

This thesis has shown that science and scientific knowledge does not tend to be recognised as a 'normal' part of WBWC households, except when children are young (*see* sub-section 8.2.1). I argue that the increasing presentation of scientific knowledge as academic rather than practical throughout secondary school and beyond (Lyons, 2006) cements its construction in White working-class families as abstract knowledge that can't be owned (Birke & Whitworth, 1998). This cultural 'splitting' (Luttrell, 2005) pits forms of personalised, practical White working-class knowledge about science against academic, abstract (middle-class) knowledge about science. Similarly, L. Archer, DeWitt, Osborne et al. (2013) described how classed discourses align working-class students with the body/underachievement rather than the mind/achievement to explain working-class students' lack of science aspirations. Thus, while White British working-class scientific knowledge can hold use-value for the holders of the knowledge, it is fixed to their body and is not easily converted for symbolic science-related cultural capital.

This dichotomy of body/mind illustrates how what is venerated in one field can be disparaged in another. Indeed, such denigrating practices occur within both racism

and classism, as dichotomies are used to 'other' non-dominant scientific experiences, knowledge and ways of being, while at the same time idealising the White, middle-class scientific logical and rational knower (Barker, 1996; Collins, 1991; Luttrell, 2005). It is argued that the suppression of scientific knowledge produced by oppressed groups such as the WBWC facilitates the continued control over science by dominant groups, who present those from marginalised backgrounds as having a "seeming absence of an independent consciousness" and therefore appear to "willingly collaborate in their own victimisation" (Collins, 1991, p.5). Thus, the false dichotomy created between academic/abstract and practical/personal forms of science-related cultural capital knowledge is indicative of the power of intersectional oppression. This is especially true for White working-class females, whose so-called 'women's knowledge' is produced in the private domestic sphere, while White working-class men at least can achieve some legitimacy amongst their peers in a practical, skilled working environment (Barker, 1996; Luttrell, 1989).

8.2.3.4. Is scientific culture hostile to WBWC culture?

Exploring WBWC students' experiences in science in both in-school and out-of-school contexts has provided an overall picture of how the 'class' of WBWC habitus can come to be mediated through the habitus of the science classroom. The class of WBWC habitus has been described here and elsewhere as comprised of dispositions such as: expertise based on first-hand experience, either within the home for women or from a communally-taught skill or trade for men (Luttrell, 1989); egalitarianism, or 'being no better than anyone else' (Stahl, 2016); following lower-status, but lower-risk pathways (L. Archer & Hutchings, 2010; Reay, 2001a); impatience based on pressures of economic necessity (Kowalczyk, Sayer et al., 2015); parents being 'watchful and concerned' but not tending to intervene in their child's education (Lareau, 2011); 'making do' with being in an undesirable situation (Bourdieu, 1990); women being caring and respectable (Skeggs, 1997) and men being physically strong and dependable (Ingram & Waller, 2014).

Meanwhile, the 'class' of science classroom habitus can be described as composed of the following dispositions: preferring a 'chalk and talk' pedagogical style which transmits scientific facts to students (Lyons, 2006); focusing on decontextualised,

abstract content which is devoid of emotion and intuition (Lemke, 2001; Lyons, 2006; Snow, 2010); prizing high-risk, exclusive routes which give long-term rewards (Claussen & Osborne, 2012); highly competitive and aggressive practices (Adamuti Trache & Andres, 2008; Calabrese Barton & Tan, 2009; Carlone & Johnson, 2007; Clark Blickenstaff, 2006; Lemke, 2001). Such dispositions can also be argued to align closely with the habitus of White, middle-class masculinity. Indeed, it is suggested that White middle-class masculine characteristics have high exchange-value in science fields *because* these fields were produced by those holding them. The positioning of science as 'culturally neutral' therefore masks the unequal exchanges undertaken within the field by those who align themselves closely with White, middle-class masculinity for the most symbolic, high-status science-related cultural capital.

Overall, the contrast between the habitus of the science classroom and the WBWC habitus is stark, and it is little wonder that the WBWC students in this study found themselves the subject of a 'habitus tug' when they became increasingly aware of the incompatibility of science with their WBWC identities. That this happens during adolescence is of particular note, as has been argued WBWC students are more likely to be susceptible to gendered and classed stereotypes during this period (Croxford, 2006). Nevertheless, it is proposed that the habitus tug these students were experiencing is a false tension, produced as the result of the science classroom's presentation of a 'cultural arbitrary' or 'the way things should be' in science. (Bourdieu, 1990). This is not a new finding – a number of scholars have challenged the narrow conceptualisation of science as it is constructed in the science classroom, arguing that it does not necessarily represent dominant scientific practices (such as the importance of collaborative working (Luehmann, 2009)) and marginalises groups who do not align with the culture of the science classroom, thereby limiting the possibilities of what science can achieve (*see* Chapter Two). However, this thesis argues that, due to the extent of the discrepancy between the White British working-class habitus and the habitus of the science classroom, WBWC students, particularly WBWC females, are at a distinct disadvantage.

8.3. Conclusion

This thesis traced the complex trajectories of twelve White British working-class students throughout their compulsory science education. In exploring their experiences of out-of-school and in-school science this thesis found, unsurprisingly, no one single reason why WBWC students are under-represented at science A Level. Nevertheless, it is believed the findings of the thesis, which has taken a novel Critical Realist approach, have improved understanding of the possible mechanisms generating the under-representation of WBWC students from post-16 science fields.

One of the proposed mechanisms is the nature of scientific culture as it currently stands in the UK's formal education field, which is argued to be inimical to many traditional WBWC cultural dispositions and forms of scientific knowledge. The value traditionally placed by those from WBWC backgrounds on practical skills, personal experience and the spirit of 'egalitarianism' is fundamentally at odds with the academic, abstract 'exceptionalism' of formal science education – values which align closely with the White middle-class masculine dispositions on which the field of science was constructed. The incongruence between the field of school science and key WBWC cultural dispositions is exemplified through the Double Science vs. Triple Science routes, which tend to divert WBWC students away from the pathways most associated with ongoing science participation, even those who would usually be considered 'highly able'. A further proposed mechanism is the hands-off but 'watchful and concerned' parenting approach generally taken by WBWC parents. In giving their children autonomy over how to spend their time out-of-school, WBWC youth increasingly focus on developing 'adult' WBWC dispositions, which results in science being constructed as something for school and no longer for home. This child-rearing approach also means that WBWC parents are less likely to intervene in their child's schooling and, therefore, use the sorts of strategies (such as the conversion of forms of capital) that many White middle-class parents and Minority Ethnic parents engage in to secure their children's educational success in science.

In addition to these theoretical contributions, this study has presented a methodological contribution in the form of a Bourdieusian-informed typology of out-of-school science engagement activities, which was based on how strongly an activity

was associated with dominant science-related cultural capital. This tool was used to describe the sorts of science-related activities WBWC students engaged in during their leisure time, which is itself an empirical contribution. The use of the tool also led to the finding that the practice of familiarisation with 'cold', abstract knowledge and academic language at home was a better indicator of ongoing science participation than engagement in science-related activities strongly associated with dominant science-related cultural capital. In other words, the development of academic dispositions is more important than the development of scientific dispositions for facilitating success in science. This was considered to be a vital clue in identifying the generative mechanisms discussed above.

In conclusion, the combination of the two generative mechanisms described above, i.e. the tension between the White, middle-class, masculine values which constitute the school science field and key WBWC values often played out in their approaches to education imply that one cannot *be* White British working-class and be successful in (formal) science. Indeed, the hostile nature of the culture of science signifies that WBWC students are particularly disadvantaged in the field of science education. This is a significant concern for several reasons: the marginalisation of WBWC students in school science contributes towards the reproduction of the exclusive nature of science more generally, as well as the pathologising discourses which surround WBWC students and their families. Beyond the classroom, science is a prestigious field which can lead to high-status, high-income professions; in diverting WBWC students away from science A Level courses such pathways become restricted to them – which is a social justice concern. Finally, this thesis has demonstrated that science is a subject which is intrinsically interesting to many people from WBWC backgrounds; WBWC students interested in continuing their science participation should be able to do so, regardless of their future intentions, and not be penalised because they don't know the 'know the rules of the game'.

8.4. Limitations of the study

This study has sought to improve understanding of WBWC under-representation in science. The findings described in this thesis have been based on a detailed empirical investigation into how WBWC values and practices interact with the field of science

to produce a tendency for WBWC students not to take up science A Levels. This study has produced several contributions: empirical, theoretical and methodological. However, as with any study there are some limitations. Chapter Four has detailed the methodological limitations of this study, thus this section discusses some theoretical limitations arising from the analysis of the interview data, which should be considered alongside the findings.

The non-deficit approach to this study involved identifying instances of WBWC science-related cultural capital with use-value in participants' interviews. It is possible that far more evidence of such cultural capital could have been identified with the use of an alternative method, such as participant observation, but this carried with it its own methodological limitations (*see* Chapter Four, sub-section 4.3.2). As a result, the analysis of participants' use-value science-related cultural capital could be considered as somewhat limited. Nevertheless, the focus of this research was what WBWC students' out-of-school science engagement and navigation of Double vs. Triple Science could reveal about the tendency for WBWC students not to continue with post-compulsory science participation. The findings related to this focus are considered to be the main contributions of this study.

A limitation of a Bourdieusian approach was the underdevelopment of his theory regarding gender and ethnicity, and how this intersects with social class. To remedy this shortcoming, the thesis drew on intersectional research, such as gender studies related to WBWC students and educational success (e.g. L. Archer, Halsall et al., 2007a; Ingram, 2011; Stahl, 2016). Nevertheless, 'Whiteness' was a difficult concept to analyse in the data, possibly as a result of what Skeggs calls "the normalisation of knowledge in the production of research" (Skeggs, 1997, p.36). While it can be claimed there are acknowledged similarities between how White working-class and certain Minority Ethnic students are pathologised in education, (L. Archer & Francis, 2010; L. Archer & Yamashita, 2003), the greater attention given to social class in the analysis of this thesis was an attempt to shift focus away from public and policy discourses which explain WBWC disadvantage as a result their being 'race victims' of multiculturalism, or as morally and culturally deficient, rather than due to structural inequalities (The Runnymede Trust, 2009).

This study used a model of habitus which recognises multiple habitus within a larger 'class' of habitus (*see* Chapter Three, sub-section 3.3.2). Nevertheless, the analysis in this thesis particularly drew on literature which described dispositions associated with the class of WBWC habitus and the implications of this on WBWC students' engagement with science. It did not explore the interaction of WBWC participants' individual habitus with the field of science, for example the extent of the impact a family member's illness had on a student's construction of science and scientific knowledge as something personal and worth knowing (*see also* Chapter Four, section 4.6.). While this would have been of interest, it was not within the scope of this study to add this additional layer of complexity to the analyses.

Another consideration is the reliance within my analyses on descriptions of the class of White British working-class habitus which appear to have been largely generated by academics who (likely) cannot claim to have insider knowledge of such dispositions. For example, Pierre Bourdieu, whose family background has been described as 'modest' but also 'lower middle-class', developed his theories in the French context (M. J. Grenfell, 2014; Rey, 2014). Even as an academic from a WBWC background, I acknowledge the complexities surrounding my position as an insider/outsider researcher (*see also* Chapter Four sub-section 4.2.5). This issue returns to the wider discussion regarding whether/how one can retain a WBWC identity if one's individual education and profession is predominantly situated in middle-class fields. Furthermore, this highlights the lack of power the White British working classes have in defining and shaping how their identity is presented in academic discourses, even if the desire of researchers is to present them in a non-deficit light. I do not believe this point undermines the validity of this study, however I recognise that I could have aligned even further with the axiological perspective of the transformative paradigm (*see* Chapter Four sub-section 4.2.4) by returning to discuss my analyses with participants and allowing them the opportunity to give input on how their dispositions were described to "determine the local meanings attached to experiences" (Mertens, 2012, p.223).

Finally, in accordance with critical realism, I am mindful of the fallibility of the knowledge created from this study due to the findings being historically, socially and

culturally situated (M. Archer, Decoteau et al., 2016; Sayer, 2000). This means that they may not be representative of the White working classes in other countries, nor will they necessarily remain appropriate explanations for patterns of WBWC science participation in the future. Despite these limitations, this research offers several original contributions which have implications for policy, practice and research. These are discussed in the next section.

8.5. Implications for research, policy and practice

As previously stated, this thesis found no one single cause of WBWC under-representation in post-16 science fields, instead it is acknowledged that the findings imply large cultural and structural disadvantages at play, which are unlikely to be rectified in the short-term and perhaps in the long-term without significant shifts in educational and scientific culture. Nevertheless, several recommendations can be made which may pave the way for meaningful change.

The first recommendation of this thesis relates to evidence from this study that WBWC students respond to group work in science education as enabling them to be authors of their own learning (*see* Chapter Six, section 6.4). As co-producers of scientific knowledge, rather than passive recipients – as is typical in the science classroom, WBWC students are more likely to feel ownership over scientific expertise (*see also* Chapter Five, section 5.2.2. *and* sub-section 8.2.3.3.). Furthermore, this has also been argued to be a more authentic reflection of the nature of scientific research (*see above*). It is proposed that **policymakers and practitioners of science education should foreground the importance of collaboration in science through increased use of group work in the classroom, especially in assessment.** For example, a student's ability to work in a team should be used an assessment indicator. This should also contribute towards reconstructing a more egalitarian science field, which currently disproportionately rewards those who thrive in individualist and competitive practices (*see* sub-section 8.2.3.1).

The second recommendation is based upon the study's identification of female WBWC students being positioned at the nexus of gendered, classed and racialised inequalities within science fields (*see* Chapter Six section 6.3 *and* Chapter Seven sub-

sections 7.2.2. and 7.3.3.). It is argued that WBWC girls are even more disadvantaged in science than so-called 'poor (White) boys', who are frequently the subject of moral panics (Francis, 2006). Given the additional finding that WBWC females tend to place a value on scientific knowledge which has been derived from subjective, personal experiences (*see* Chapter Five sub-section 5.2.2.) – knowledge which is likely to be misrecognised and negated within the science classroom (O'Loughlin, 1992) – it is recommended that, **the science curriculum should be made more adaptable to allow WBWC students to draw on use-value scientific knowledge based on personal history**. This should support female WBWC students' learning in science, as well as provide an opportunity for them to claim ownership over scientific knowledge and a form of expertise in science more generally. **Furthermore, this flexible approach should be extended to science assessment, to demonstrate schools' advocacy of different forms of scientific knowledge**. For example, the introduction of a coursework assignment where students can draw on a subject of personal interest and investigate it empirically or theoretically in relation to more traditional, canonical forms of science.

In light of the finding that not all out-of-school science activities are equal as sources of embodied science-related cultural capital, this thesis recommends that **school-based science activities such as Science/STEM clubs should be made more accessible and attractive to students from WBWC backgrounds by reflecting a range of practical *as well as* academic values, showing them as not distinct but inter-related**. In these activities, students should be made aware how scientific skills or concepts are also relevant to their everyday lives, possibly tying them to students' current leisure activities such as sports. In doing so, schools can establish a literal, physical version of Calabrese-Barton et al.'s dialogic 'hybrid spaces' which helped disadvantaged youth in the U.S. generate epistemic authority in the science classroom (Calabrese Barton, Tan et al., 2008). Furthermore, the longitudinal nature of the data illustrated a significant drop in WBWC out-of-school science engagement when they reached secondary school. **It is suggested that relevant parties co-develop with WBWC teenagers a range of visible and accessible science activities that are age-appropriate for WBWC students at the beginning of adolescence.**

Furthermore, funding should be allocated to support long-term projects which enable WBWC students to maintain out-of-school science engagement throughout the transition between primary and secondary school.

A final recommendation of this thesis is related to the Double and Triple Science streams. This thesis has discussed the role the dual streaming of science has in reproducing social inequalities, adding an extra layer for WBWC students compared to other subjects by reinforcing 'exceptionalist' discourses surrounding science which are in tension with White working-class values of 'egalitarianism' (*see* Chapter Seven, section 7.5). As discussed in Chapter Seven, knowledge about institutionalised forms of cultural capital plays a key role in choice of future educational pathways, however students from different socioeconomic backgrounds have unequal access to this knowledge, with students from middle-class backgrounds being more advantaged in this respect (Bourdieu & Passeron, 1979). In light of the finding of this thesis that WBWC students are likely to be located in areas of restricted access to Triple Science, and remain uninformed of the exchange-value of Triple Science in further education and labour markets, **it is strongly recommended in the short-term that all students are given a free choice to take Triple Science** which is not restricted by them having to give up a GCSE option, or because it is not accommodated in the school timetable. **In addition, WBWC students should be made aware of the range of advantages of taking Triple Science when making the choice.** Furthermore, it has been argued in Chapter Seven that giving WBWC students' 'choice' of qualifications is problematic and questions the viability of the Double Science route as a legitimate pathway for WBWC backgrounds to continue participating in science. Therefore, in the medium-term – in line with recommendations from the ASPIRES project (L. Archer, Moote et al., 2016b) – **this thesis calls for the replacement of dual science streaming with a single science award that is for all**.

8.6. Directions for future research

The findings within this thesis have built on existing research to provide new insights into White British working-class engagement with science and shed light on the causes behind WBWC under-representation in post-16 science fields. This section

focusses on a number of areas for further research which have been generated from the findings, recommendations and limitations of this work.

As discussed in Chapter Four, this thesis was primarily built on interview data which provided personal accounts of WBWC students' engagement with science both in-school and out-of-school. In doing so, the thesis prioritised the students' own stories and constructions of science, rendering them 'visible' as players of the game (Reay & Lucey, 2003). Nevertheless, a gap remains in directly observing WBWC students' science engagement, particularly in structured out-of-school science activities. An ethnographic study situated in areas serving WBWC communities would further improve understanding of the role of out-of-school science activities for WBWC students' engagement in science. Such research also offers the potential for more specific recommendations regarding making such out-of-school science activities more accessible to WBWC students. A suggested research question in this area would be: *In what ways do White British working-class youth experience structured, out-of-school science activities?*

Somewhat related to this suggested new area of research is a study exploring WBWC engagement in Public Engagement in Science (PES). Public Engagement in Science initiatives have been put forward as ways to manage the relationships between society and science, fostering dialogue and trust between multiple publics and the scientific community (Nisbet & Scheufele, 2009). As discussed in Chapter Five, 'visiting a science centre, science museum or zoo' was the least common out-of-school science activity for WBWC families. This phenomenon has also been noted by Dawson (2012), who suggested families from WBWC backgrounds do not tend to participate in PES. In response to this problem, it is suggested that empirical research is needed to understand the reasons this may be, and to explore any relationships between WBWC non-participation in PES and differentiated engagement with science activities more generally. Research could address questions such as: *What factors influence WBWC non-participation in PES? What is the relationship between WBWC participation in PES and WBWC students' engagement in formal science education?*

As noted in the Chapter Four, it was beyond the scope of this thesis to collect interview data from participants' science teachers. However, it is arguable that approaches to educational research which draw on Bourdieu's notions of pedagogic action should seek opportunities to obtain data from the system of agents who exert it (Bourdieu & Passeron, 2000). Thus, a natural extension of the research covered in this thesis would be to interview science teachers based in schools serving WBWC communities, to examine their accounts of WBWC engagement in science. Taking the lead from existing work exploring teachers' constructions of Minority Ethnic and working-class students in education more widely (e.g. L. Archer & Francis, 2010; L. Archer, Halsall et al., 2007b; Francis & Archer, 2005; Reay, 2001b), a suitable research question might be: *Which discourses do science teachers draw upon when constructing White British working-class students' identities in science education?*

One of the main foci of this thesis was examining the effect of the hierarchical structure created by Double and Triple Science awards on WBWC participation in post-16 science fields. However, the dual streaming of GCSE science awards is not the only practice in formal science education which may disadvantage students with the 'wrong' cultural dispositions. Exams and assessments have also been highlighted as forms of sorting and selecting practices used to position agents (students) in a social hierarchy differentiated by their cultural capital (P. Thomson, 2005). There is scope, therefore, for an empirical study to explore how differing approaches to exams and assessment influence WBWC student participation in science. Suggested research questions include: *What is the relationship between differential science assessment practices and WBWC participation in post-compulsory science? How does the intersection of class, race and gender inform WBWC students' identities during science assessment activities?*

In a similar vein, based on the finding of this thesis that WBWC students do not tend to feel 'at home' in academic environments, an important area of research would be to follow WBWC students who take science qualifications that are alternatives to the 'gold standard' of A Levels, for example the Applied Science BTEC. Such research could investigate the experiences of WBWC students while taking these qualifications, following them as they progress to their post-FE destinations.

Questions for this research could be: *In what ways do White British working-class youth experience non-traditional science pathways? What is the relationship between non-academic science qualifications and post-18 science participation for WBWC students?*

Among the limitations of Bourdieu's work has been the criticism that his focus on structural positioning has resulted in the neglect of the content and internal structuring of knowledge within a given field (Naidoo, 2004). A closer examination of the structuring of knowledge in the field of science education, using Bernstein's (2000) theories on knowledge systems, could help overcome concerns associated with Bourdieu's "absolute substantive theory of arbitrariness" (Li Pulma, 1993, p.17). Such research would provide critical discussion of the *raison d'etre* of science and bring focus to why certain forms of scientific knowledge are considered, as Maton (2006) suggests, 'sacred' while others are 'profane'. A suggested starting research question for the study would be: *What do Bernstein's theories of knowledge structures reveal about the specialisation of scientific knowledge within the formal science education field?*

8.7. Final remarks

This study has sought to improve understanding of WBWC students' tendencies not to continue with science at A Level. This was based on evidence that WBWC students are under-represented in post-compulsory science fields and driven from a personal and professional desire to critically examine the viability of science enrichment activities to widen participation in science for students from WBWC backgrounds.

The findings of this study suggest that the cultural arbitrary of science as an elite and abstract discipline continues to deter many WBWC students from ongoing science participation. As science A Level qualifications remain a significant form of symbolic capital (Education Standards Analysis Research Division, 2011; Parliamentary Office of Science Technology, 2013; P. Thomson, 2005), the unequal distribution of such capital only adds to a wider system of social reproduction which marginalises those from WBWC backgrounds. Furthermore, the narrowing of the sociocultural profile of those who take science A Levels arguably continues in the high-status science courses

at university, and again within science professions. By disrupting patterned relations of race, gender and class inequality in science, we can look to address social justice issues *and* improve the breadth, quality and innovation of scientific research. Furthermore, if more students from WBWC backgrounds have post-compulsory qualifications in science, and perhaps more importantly, feel *at home* in science, they are more likely to have the agency to engage in science-related fields outside of – and beyond – formal education. This can lead to additional opportunities to develop their scientific literacy, confirm that their ideas and opinions about science have validity within the public sphere and enable them to become a source of embodied science-related cultural capital themselves (Dawson, 2012; Mendick, Berge et al., 2017a).

In exploring the nature of WBWC engagement with in-school and out-of-school science, this study has provided empirical evidence which challenges deficit discourses surrounding the White British working classes. Through longitudinal interviews with participants, this thesis has demonstrated the complexities of WBWC engagement in science more generally, particularly as they enter adolescence, as WBWC students' personal interest in engaging with science interacts with gendered, classed and racialised ideas about whether science – either at home or in school – is within the limits for someone like them. As M. Archer, Decoteau et al. (2016, p.3) note, in order to do justice to the heterogeneity and intricacy of the social world one must provide a "thick and robust account of causation, structures and processes". It is hoped that this thesis has delivered such an account, and in doing so contributes towards a body of research which seeks to address inequalities in science education.

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Appendices

Appendix 1: Ethics and consent documents

Letter of ethical approval from King's College London for ASPIRES2

<div align="right">

Research Ethics Office

King's College London

Rm 5.2 FWB (Waterloo Bridge Wing)

Stamford Street

London

SE1 9NH

</div>

1st April 2014

TO: Dr. Jennifer DeWitt

SUBJECT: Approval of ethics application

Dear Jennifer,

REP/13/14-53 - Young People's Science and Career Aspirations age 14-19 (ASPIRES2)

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 **1st April 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

NOT APPROVED/APPROVED/APPROVED PENDING/REFERRED (Delete as appropriate)
Primary Comments:
Further Amendments to Application (please identify the relevant section number before each comment):
Amendments to Information Sheet and Consent Form:
Information Sheet: - Please inform participants that you will be using the DfE database to access their student records. - Participants who provide their names should be given the opportunity to withdraw their data from the study; please outline and distinguish the withdrawal processes for those participants who provide their names and for those who don't. Information Sheets & Consent Form for interviews: - Please give a specific date, after which participants may no longer withdraw their data from the study.

Student information sheet for ASPIRES2

Information Sheet for Participants (Students)
14/11/2014

REC Reference Number: REP/13/14-53

Aspirations and Careers in Science (ASPIRES2): Age 14-19

We would like to invite you to continue to participate in a research project about science and future careers. You should agree only if you want to; choosing not to take part will not disadvantage you in any way. Please read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

What is the purpose of this study?
We want to find out more about what young people think about science. We also want to find out about how you make choices about your education (e.g. what subjects to study at GCSE) and about how you are making plans for your future. All of these things will help us improve science education and careers education.

Why have I been invited to take part?
You have been asked to take part because we interviewed you in years 6, 8 and 9 as part of the ASPIRES project. We now are able to continue with the project and we hope to find out how your thoughts and ideas area changing as you get older.

Do I have to take part?
You do not have to take part. You should read this information sheet and ask any questions you have. If you do not want to take part, you can tell your parent.

What will happen if I take part?
You will participate in two more interviews with us, when you are in year 11 and year 13, most likely at your school but we could also conduct them at home if you prefer. These interviews will again last around 30 minutes and will be similar to the previous interviews, talking about science and other subjects in school, what they might want to do in the future and the kinds of things you're interested in.

It is up to you to decide whether to keep taking part or not. You are free to stop participating at any time. You don't have to give a reason. You may also withdraw your data from the project at any time, up to 1 August 2017. Recordings will also be wiped upon transcription.

There are no foreseeable risks in taking part.

Will my taking part be confidential?
What is said in the interviews is considered confidential and will be held securely until the research is finished. If you change your mind about participating, let us know and

we'll remove the data. We can do this until 1 August 2017. We will not tell your teachers, other members of staff, other students or your parents what you have said.

The UK Data Protection Act 1988 will apply to all the data we collect. We will hold the information on password-protected computers and in locked file cabinets at King's College London. On completion of this research project an anonymised data set may be deposited on the UK National Data Archive. Interview data will be accessed only by the researchers and a transcriber and we will protect your anonymity by using false names.

Who has funded this research?
The project is funded by an organisation called the Economic and Social Research Council (ESRC).

What will happen to the results?
We will write reports about the research for conferences, teachers and other researchers. These reports may also be used by policymakers and other organisations to improve science and careers education. Neither you nor your school will ever be named in the reports.

What if I have other questions?
If you have any questions or need more information, please contact me using these details:
Dr Julie Moote
King's College London
020 7848 3087
julie.moote@kcl.ac.uk

If this study has harmed you in any way or if you wish to make a complaint you can contact King's College London using these details: The Chair, Social Science and Public Policy, Research Ethics Subcommittee, rec@kcl.ac.uk

Thank you for reading this information sheet and considering taking part in this research.

Student consent form for ASPIRES2

CONSENT FORM FOR PARTICIPANTS IN RESEARCH STUDIES

Please complete this form after you have read the Information Sheet.

Title of Study: Aspirations and Careers in Science (ASPIRES2): Ages 14-19

King's College Research Ethics Committee Ref: *REP/13/14-53*

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions based on the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You can contact me via email: julie.moote@kcl.ac.uk. You will be given a copy of this Consent Form to keep and refer to at any time.

Please tick or initial

- I confirm that I have read and understood the information sheet dated 14/11/2014. I have had the opportunity to consider the information and asked questions which have been answered satisfactorily.

- I understand that if I decide at any time during the research that I no longer wish to participate in this project, I can notify the researchers involved and withdraw from it immediately without giving any reason. Furthermore, I understand that I will be able to withdraw my interview data up to 1 August 2017.

- I consent to the processing of my personal information for the purposes explained to me. 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 an interview as part of this research project.

- I understand that confidentiality and anonymity will be maintained and it will not be possible to identify me in any publications.

- I consent to being audio recorded as part of the interview.

Participant's Statement:

I, _____ (your name), agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves.

Signed   Date

Investigator's Statement:

I _____

Confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Signed   Date

Parent information sheet for ASPIRES2

Information Sheet for Parents
14/11/2014

REC Reference Number: REP/13/14-53

Permission for you and your child to participate in a research project: Aspirations and Careers in Science (ASPIRES2): Age 14-19

You and your child are being invited to take part in this research study, which is a continuation of the ASPIRES research project which you participated in starting in 2010. 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 me if anything is unclear or if you would like to know more. Take time to decide whether or not you wish to take part.

What is the purpose of this study?
The project aims to find out more about young people's attitudes towards science and to encourage them to consider careers in science or careers that use science skills. The project builds upon the earlier ASPIRES research project, which you also participated in and which explored attitudes and aspirations in children ages 10-14. In this phase of the project, we hope to continue to explore how young people and their parents think about science and how they make decisions related to education and future careers.

Why have I and my son/daughter been invited to take part?
You and your son/daughter both participated in interviews in the original ASPIRES project.

Do we have to take part?
You and your son/daughter do not have to take part. You should read this information sheet and ask the researcher any questions you have.

What will happen if we take part?
Your son/daughter will participate in two more interviews with us, when he/she is in year 11 and year 13, most likely conducted at their school but we could also conduct them at home if you and your child prefer. These interviews will again last around 30 minutes and will be similar to the previous interviews, talking about their experience of science and other subjects in school, what they might want to do in the future, the kinds of choices they're making about their education and the kinds of things they're interested in.

We also hope to interview you two more times – once when your son/daughter is in year 11 and once when they are in year 13. These interviews will also be similar to previous interviews, lasting around 30 minutes and talking about your child's experience of school and science, the choices they're making, their aspirations and interests and your own thoughts about science.

We hope that you and your child will enjoy participating in the interviews again. We do not expect you or your son/daughter to experience any negative effects. You or your child may withdraw from the study at any time, without giving a reason. You or your son/daughter may also withdraw your data from the project at any time, up to 1 August 2017. Recordings will also be wiped upon transcription.

Only the researcher and the transcriber will hear the recordings. The transcriber will be required to sign a confidentiality agreement as a condition of employment. Written examples may be used in reports, but you and your son/daughter will be completely anonymous.

What are the possible risks?
There are no foreseeable risks in taking part.

Will our taking part be confidential?
What is said in the interviews is considered confidential and will be held securely until the research is finished. If you change your mind about you or your son/daughter participating, let us know and we'll remove the data. We can do this until 1 August 2017.

The UK Data Protection Act 1988 will apply to all the data we collect. We will hold the information on password-protected computers and in locked file cabinets at King's College London. On completion of this research project an anonymised data set may be deposited on the UK National Data Archive. Interview data will be accessed only by the researchers and a transcriber and we will protect your and your child's anonymity by using false names.

Who has funded this research?
The project is funded by an organisation called the Economic and Social Research Council (ESRC).

What will happen to the results?
We will write reports about the research for conferences, teachers and other researchers. These reports may also be used by policymakers and other organisations to improve science and careers education. Neither you, your child nor your child's school will ever be named in the reports.

What if I have other questions?
If you have any questions or need more information, please contact me using these details:
Dr Julie Moote
King's College London
020 7848 3087
julie.moote@kcl.ac.uk

If this study has harmed you or your child in any way or if you wish to make a complaint you can contact King's College London using these details: The Chair, Social Science and Public Policy, Research Ethics Subcommittee, rec@kcl.ac.uk

It is up to you to decide whether or not to give permission for you and your son/daughter to participate. If you do decide to give permission, please keep this letter and sign the consent form. The consent form should be returned to the researcher at the address below. If you decide to give permission, you and your son/daughter are free to withdraw at any time and without giving a reason.

Thank you for reading this information sheet and considering continuing participating in the ASPIRES research.

Yours sincerely

Dr Julie Moote
King's College London
Parent consent form for ASPIRES2

CONSENT FORM FOR PARTICIPANTS IN RESEARCH STUDIES

Please complete this form after you have read the Information Sheet.
Title of Study: Aspirations and Careers in Science (ASPIRES2): Ages 14-19
King's College Research Ethics Committee Ref: *REP/13/14-53*

Thank you for considering giving permission for you and your son/daughter to take part in this research. The person organising the research must give an explanation of the project to you before you agree to your child's participation. If you have any questions arising from the Information Sheet given to you, please ask the researcher (Julie Moote) before you decide whether to allow your child to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

Please tick or initial

- I confirm that I have read and understood the information sheet dated 14/11/2014 for the above study. I have had the opportunity to consider the information and asked questions which have been answered satisfactorily.

- I understand that if I decide at any time during the research that I no longer wish for my son/daughter to participate in this project, I can notify the researchers involved and withdraw from it immediately without giving any reason. Furthermore, I understand that I will be able to withdraw my son/daughter's interview data up 1 August 2017.

- I consent to the processing of my son/daughter's personal information for the purposes explained to me. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.

- I understand that my son/daughter's data may be subject to review by responsible individuals from the College for monitoring and audit purposes.

☐

- I consent to my son/daughter taking part in an interview 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 son/daughter being audio recorded as part of the interview.

☐

- I understand that if I decide at any time during the research that I no longer wish to participate in this project, I can notify the researchers involved and withdraw from it immediately without giving any reason. Furthermore, I understand that I will be able to withdraw my interview data up August 2017.

☐

- I consent to the processing of my personal information for the purposes explained to me. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998.

☐

- I understand that my data may be subject to review by responsible individuals from the College for monitoring and audit purposes.

☐

- I consent to taking part in an interview as part of this research project.

- I understand that confidentiality and anonymity will be maintained and it will not be possible to identify me in any publications.

☐

- I consent to being audio recorded as part of the interview.

Parent/Guardian's statement (on behalf of the young person):

I _____(insert your name) agree that the research project named above has been explained to me to my satisfaction and I agree to let my son/daughter:

_____ (insert your son/daughter's 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.

Signed   Date

Relationship to Child: Father   Mother   Guardian   Other   (Please circle)

Participant's Statement:

I, _____ (your name), agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves.

Signed   Date

Investigator's Statement:

I _____

Confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Signed   Date

Appendix 2: Participant biographies and working-class classification data

Biographies for both student and parent participants, including social class indicators derived from the interview data

Bobster

Bobster attended a mixed comprehensive school in the south of England until the age of 16. From the end of primary school (and possibly before) until age 15 Bobster had strong and consistent aspirations to be an architect, undertaking a range of related activities at home. Between the end of ASPIRES1 and the beginning of ASPIRES2 (while aged 15/16) Bobster's career aspirations changed to be a policeman. Bobster had been on track to complete the Triple Science award however in the second year of his GCSEs, his teachers decided to enter him for the Double Science award on the grounds that he was struggling with his coursework. In his GCSEs Bobster obtained 4Bs, 4Cs, 2Ds and 1E, including B-C in Double Science. Following from his GCSEs Bobster undertook a course in Public Services at a local Further Education college. His intention in year 11 was to be a military police officer when he leaves college until he is 21 when he can change to be a civilian police officer. Bobster held generally very positive views about science throughout ASPIRES1, which he reported as increasing throughout the duration of the project; he was in his secondary school's science club until it closed due to lack of staff, had been in the top sets for science and maths, had engaged in a substantial number of science-related activities outside school and was intending to study it beyond GCSE. In ASPIRES2 Bobster reported being less interested in science and opted not to continue studying beyond GCSE, this marked a significant shift away from his intentions as articulated in ASPIRES1.

Bobster's mother, **Martha**, is widowed. Bobster's father was previously a mechanic and then an asbestos surveyor before he died. Martha left school after her O Levels, when she was 16, has formerly worked as a carer for an elderly couple but since they died has been a dog sitter for the couple's daughter. Martha had high aspirations for Bobster pursing an academic education and then a successful career with a good salary, she was hoping he would drop out of his college course and start A Levels as originally planned. She has reported generally positive views of science, throughout ASPIRES1 and ASPIRES2, particularly from the perspective of it being a useful academic subject for her children. However, she did make associations between science and negative views she holds about her own academic ability from her school days.

Social class indicator: Martha described her and her husband as coming from poor backgrounds and that they struggle financially as a family, which is a clear indicator of low levels of economic capital. She mentioned operating a strategic approach in choosing which extra-curricular activities Bobster did as a child, showing some

recognition of the notion that certain practices had more cultural capital with exchange-value than others, however this was not sustained beyond his early childhood and actually his extensive and quite impressive activities as a scout leader were instead seen by Martha as a hindrance to his academic studies. Finally, Bobster's family did not have the social capital to realise Bobster's aspirations of doing work experience in an architectural firm and instead their connections led him to work in a computer game shop.

Celina

Celina attended a mixed comprehensive in east London until the age of 16, when she moved to a local FE college. Throughout ASPIRES1 and continuing into ASPIRES2 she has had consistent aspirations to be a teacher although she has also more recently expressed an interest in writing fiction. Celina had been offered by her school to do Triple Science but opted to do Double Science because she hadn't enjoyed science that much and had concerns it would be too hard. In her GCSEs, Celina obtained mostly As and Bs with a B-C in Double Science. After her GCSEs, Celina changed to attend a local FE college to do A Levels in English Literature, Psychology, Religious Education and Geography. At this point she expressed a desire to go to university and was quite determined to get there. Celina's views of science improved in ASPIRES2, and she articulated that she would have liked to switch from Double Award to Triple Award science for her GCSEs. She had expressed at the beginning of ASPIRES2 that she would like to continue studying science for her A Levels, although she was concerned she would fail for not having enough knowledge with the Double Science award.

Celina's mother, **Leah2**, left school at 16 and had Celina shortly afterwards. She is separated from Celina's dad and currently works at a bookmaker/betting shop. Leah doesn't like to be too pushy regarding Celina's schoolwork or social activities but aspires for her to do well and 'go further than she did'. She would like Celina to go to university and earn a good wage. She is clear that she has no interest in science and never has done, having been put off from science at school due to a dissection practical, which she didn't enjoy.

Social class indicator: Leah2 and Celina live a small high-rise flat in East London. While it is not known whether or not Leah2 owns or rents the flat, the location, the condition and the size of the flat implies low levels of economic capital. Leah2 and her husband both left school at 16 and 15 respectively without any formal qualifications. Leah2 has worked and had training as a Nursery Nurse and used the cultural capital obtained within that experience to choose a suitable primary school for Celina. While Celina has been at secondary school however, Leah2 has chosen to not 'interfere' with Celina's schooling and social life, both trusting her to study enough and leaving her to enjoy her free time. She reported a lack of cultural capital to advise Celina regarding her school and career choices and, tellingly, Celina believes that parents are the first to

ridicule you for expressing a strong interest in something. Furthermore, they rely on the school to obtain a work experience placement for Celina, despite not agreeing with the outcome.

Charlie

Charlie attended a mixed comprehensive in Essex until the age of 16. She had fairly consistent aspirations to be a lawyer but this changed to be a police detective during her GCSEs. Following her GCSES, where she obtained 3As and 7Bs including a B-B in Double Science, she took a Public Services course at a local FE college and spoke of an intention to go to university to 'bump up' her qualifications in order to go in to the police force at a higher level. Charlie took the Double Science award despite originally hoping to do Triple Science; this was based on timetable restrictions, as she didn't want to 'lose' another subject. Her interest in science had increased over the years of ASPIRES1 but she still viewed science in quite pragmatic terms and would only choose to continue to study it beyond 16 if it was useful to her chosen career path. In ASPIRES2 Charlie reported not being interested in science due to the extensive amount of revision involved and problems with teacher turnover.

Charlie's mother, **Robyn**, left school after her GCSEs for financial reasons and has worked ever since. She works in a toyshop and her partner is a butcher. She left school at 16 after doing her GCSEs. She expressed a desire for Charlie to do A Levels and go to university and reported that she would be really proud if that were to happen but wasn't sure whether university is an option since Charlie chose not to do A Levels. Robyn expressed a general interest in science but did not make a point of specifically seeking science-related activities to do or books/magazines to read.

Social class indicator: Robyn and Charlie live in a deprived area of East London. Robyn reports that she doesn't have enough money to send Charlie to university, suggesting the family has low levels of economic capital. Robyn doesn't exhibit the cultural capital required regarding the qualifications Charlie would require to be a lawyer, just vague notions of needing to attend university, which is something Charlie herself wasn't sure of during ASPIRES1. Much like with the other participants, Robyn did not mention a vast range of social contacts for whom she can draw on for pertinent advice regarding Charlie's education and decision-making processes. She appeared to have some agency in supporting Charlie, however, and through her own effort organised for Charlie to have work experience in a local solicitor's firm.

Connie

Connie attended a mixed comprehensive in Essex until the age of 16. Initially she had expressed interest in working in a zoo or having a sports-related job such as a lifeguard or swimming instructor but this changed to aspirations in beauty when she was 14. Her GCSEs grades are unknown. As a result of her change of interest she went to a local FE college to study a course in beauty therapy. Connie had liked the idea of university but didn't know anything about it and expressed confusion during ASPIRES2

regarding the courses one could take – apparently unaware that there were different courses available at university. She articulated at this point that she would like to have her own beauty salon in future. Connie took Double Science, saying she hadn't wanted to do Triple Science, a decision for which she has since expressed regret, stating that she feels Triple Science could have helped her more in her beauty course. She has had very positive views about science in the past, agreeing at the beginning of ASPIRES1 that she would consider studying science at university. This diminished somewhat at the end of ASPIRES1 and while she reported liking certain aspects of science, particularly the experiments, it was no longer one of her favourite subjects, a feeling that continued in ASPIRES2.

Connie's mother, **Shelly**, left school after her GCSEs when she was 16. She is long separated from the father of her two older daughters (including Connie) and recently separated from the father of her youngest at the beginning of ASPIRES1. Shelly used to work in the accountancy department of a solicitor's firm but was unemployed for a long time while bringing up Connie's younger sisters. More recently she has started work as a lunchtime monitor in a local primary school with aspirations to becoming a teaching assistant. She would like Connie to travel, be successful and perhaps have her own business but ultimately settle close to home. Shelly has consistently very good views of science, having taken all three subjects separately at GCSE level. In ASPIRES2 she describes watching science documentaries with her daughters and talks enthusiastically about the holistic nature of science and how it can be present in everyday activities. She feels that Connie is pursuing a career involving science because of the scientific aspects of beauty.

Social class indicator: Shelly lived with her daughters in a hostel for a few months prior to ASPIRES1 and they now live in council accommodation. This, along with the fact that Shelly was unemployed for many years and has been on benefits, is a clear indicator of low levels of economic capital. Shelly has used her experience in a number of jobs to advise Connie on careers, however she has not displayed the cultural capital required to advise her on alternative routes and it is revealing that at the age of 16 Connie was unaware that one could take a range of different courses at university rather than just one being available. Again, the aspect of work experience was a good guide as to the levels of social capital of the family. Despite Connie wanting to go into beauty, her work experience took place in a nursery as it is where her youngest sister attends and Shelly was able to ask them, suggesting low levels of social capital.

Danielle

Danielle attended a mixed comprehensive in Leicestershire until the age of 18. She obtained 1A*, 2Bs, 2Cs and a D in her GCSEs, including a C-C in Double Science, and is now taking A Levels in Media studies, Health and Social care, History and English Language/Literature. Previously she has had aspirations to be a teacher, and then specifically a humanities teacher. She chose to do Double Science because she felt she

would have failed Triple Science, as it was 'too hard'. She has also long held an interest in being a marine biologist but she was not confident about this option, as she didn't feel she was competent enough at Biology. Danielle is determined to go to university despite a lack of encouragement from her father but has said she doesn't want to stray too far away from her mother, to whom she is very close. She has consistently expressed a strong interest and passion for science and hoped to pursue Physics as one of her A Levels however she didn't achieve the correct grades to be allowed to take the subject by her school.

Danielle's mother, **Sandra**, works as a catering manager in a primary school kitchen and her husband is a service engineer. She completed her O Levels and this was followed by a City & Guilds course in community care after which she worked briefly as an occupational therapy assistant. Later Sandra completed an A Level in English at night school. She was concerned that Danielle would not be motivated in an academic environment and therefore neither A Levels nor university would be a good fit for her. She likes the idea of Danielle being a teacher or a personal trainer because she believes she is good at organising and motivating others. Sandra has positive views of science and actively encouraged Danielle in the past to consider a science path through buying her science books and telling her she has a natural aptitude for the subject. In ASPIRES1 Sandra stated that despite personally being better at Physics, she loves human biology and would like to take an A Level in Biology to ensure she doesn't 'waste' the knowledge she is accumulating as part of her work with nutrition.

Social class indicator: Sandra has some qualifications beyond secondary school, but she decided not to pursue further qualifications in occupational therapy despite her interest in the area because she wasn't able to be supported financially by her parents. She mentions being brought up in a "typical, working-class, horrible area". She shows awareness of the need to develop cultural capital within children to support their attainment and learning, and how such practices are easier when one has more economic capital. Sandra has exhibited her own use of cultural capital when she used Ofsted reports to decide on the best secondary school for Danielle, also looking at the statistics of progression and attainment for students in the different local schools in the area. Danielle has a cousin who has a degree in chemistry, however ultimately, she wasn't able to work in the field and is now working in a nursery. This suggests the family doesn't have the cultural and social capital to convert the cousin's institutionalised cultural capital (the degree) into a successful job.

Dave
Dave attended a mixed comprehensive in East London until the age of 16. Dave's GCSE grades and post-16 destination are unknown. Dave has long-held aspirations related to art throughout ASPIRES1 and ASPIRES2, although also expressing an interest in running and business. His aspirations to run stopped in year 9 as he states he realised he couldn't compete with some of the faster students at his school. In ASPIRES2 Dave

has been fluctuating between art-related jobs, such as interior design, and business, and is keeping his options open regarding both. After school Dave has expressed he acknowledges university is a 'safe bet' and recognises the cultural capital associated with it, however he has some contradictory feelings based on his father's opinion and also likes the idea of going directly into training for a job – either in interior design or in stocks and shares. Dave started off in ASPIRES1 with very positive views about science, and often used to reading science comics as well as conduct experiments with a neighbour. He chose to take Double Science award for the sake of getting just enough of the science he needed without getting confused. During ASPIRES 2 he reports not doing science activities with his neighbour anymore and while he still enjoys the experimental side of science at school, he struggles with the academic side.

Dave's mother, **Jane2,** works in the hospitality area of a Premier League football club and as a hairdresser. She is separated from Dave and his siblings' father, who has recently started training to be a tree surgeon but is still currently working as a courier. Jane2 left school at 16 and attended a local FE college to study Art and Design and then Graphic Design. She believes that Dave is not sure what he wants to do but tries to use her resources to guide him in his choices, including securing work experience at a broker's with a friend of hers. Jane2 likes the idea of Dave having a job that will provide him with a good salary and travel, she is keen for him to not settling down to early has she believes she did. Jane2 has generally positive views of science, seeing it as located more in the school realm and occasion significant events such as the eclipse.

Social class indicator: Jane2 is a single mother with two jobs who has expressed that she works to pay for her children, suggesting low levels of economic capital. She has some obvious cultural capital in the form of further education qualifications and has exhibited the use of cultural capital in obtaining a place for Dave at a selective school. However, she admits she failed to recognise the limitations the subject sets he was put into placed on his exam attainment, something which came about through her allowing herself to be appeased by his teachers that he was doing well.

Football Master

Football Master attended a mixed comprehensive in Hampshire until the age of 16. He received As, Bs and Cs in his GCSE, after which he went to a local FE college to do A Levels in Biology, Chemistry, Maths and History as he considered them to be 'facilitating' subjects. Football Master has had consistent aspirations to be a vet, throughout secondary school. However, in year 11 he decided that he no longer wanted to be a vet and instead aimed to become a GP. Football Master has held consistently positive views about science throughout ASPIES1 and ASPIRES2 and cited this as the reason he took Triple Science as well as the extra GCSE it afforded him. During ASPIRES1 Football Master reported only reading science reference books, amongst other subjects, at home. However, when he reached secondary school he

also began to attend the school's science/STEM club, which gave him access to lots of experiments and other science enrichment experiences.

Laura, Football Master's mother, left school at 16 and currently works as a learning support assistant. Her husband works for the RAF and as a result they have moved around a lot as a family. Laura is pleased that Football Master aspirations are set on university, and is keen for him to push himself but also be happy. She expresses mixed sentiments about science throughout her interviews, reporting how she stopped studying it at secondary school because of poor experiences with her teacher, and yet appears to have a great interest in the medical side of science, particularly in relation to issues that have affected her family. Laura does not report engaging in any science activities at home throughout ASPIRES1 & ASPIRES2.

Social class indicator: Laura has reported that her and her husband do not own their own house, instead living in RAF quarters, and that Football Master is concerned about tuition fees, but intends to earn lots of money to buy his parents a house, suggesting low levels of economic capital. Laura's accounts of the difficult experiences she had with her eldest son's education and the need to 'learn from mistakes' with him, combined with comments that Football Master has a better idea than her of what is required to get into veterinary school, imply a lack of cultural capital to guide and support her children in making educational choices. Laura was not involved in organising Football Master's work experience, which was at a veterinary practice, which is usually an indicated of low levels of social capital and does not talk about any contacts or acquaintances of whom she could ask advice and support regarding her sons' education and job opportunities.

Hedgehog

Hedgehog attended a mixed comprehensive in Essex until the age of 18. His GCSE grades were not confirmed, but after Hedgehog intended to take A Levels in Economics, Business Applied, and Accounting and Film Studies (although there was an implication this may have to change based on his GCSE grades). The first three subjects because of their association with maths (and therefore relation to his favourite subject and aspiration to be an accountant), and Film Studies as a 'plan b'. Hedgehog voiced consistent aspirations throughout years 6, 8 and 9 to be a teacher, specifically a primary teacher in year 6 and 8 and then PE teacher in year 9. Hedgehog's aspirations appeared to be so clear-cut that at no point did he offer an alternative or back-up aspiration. However, in year 11 his career goal changed to be an accountant. Hedgehog generally expressed positive views about science in ASPIRES1, and particularly seemed to enjoy the practical elements of his school science lessons. His interest seems to be lessened somewhat in ASPIRES2, and he talks instead of preferring maths. Hedgehog was placed in Double Science for his GCSEs and regards himself as 'fine' with that placement, as long as he passes to be able to pursue his interest in accountancy. Hedgehog's out-of-school engagement in science appears to

drop from fairly active, regular participation with his father to occasionally watching science TV programmes throughout the course of ASPIRES1 & ASPIRES2.

Hedgehog's father, **Larry**, left school at 16 and currently works as a postman. He has expressed that he would like Hedgehog to be family-oriented, with no financial worries or health concerns and generally talks about not putting too much pressure on him to make a choice one way or another. He has expressed a consistent interest in science throughout ASPIRES1 & ASPIRES2, and actively engaged with Hedgehog to do science experiments and watch science TV programmes when he showed interest.

Social class indicator: Larry and his wife own their home in East London. He speaks at length in the interviews about concerns regarding the financial debt Hedgehog would accrue having gone to university, suggesting low levels of economic capital. Larry does convey an interest in giving his son good advice regarding his education, and while he stresses that he wants Hedgehog to enjoy his studies, Larry reports using relevant literature to be more informed, indicating agency to accumulate some cultural capital. Hedgehog did not go on work experience, as it was not offered by the school and his parents did not organise anything either, suggesting limited social capital.

LemonOnion

LemonOnion attended a mixed comprehensive in the south of England until the age of 16. After her GCSEs, where she obtained 1A*, 5As, 2Bs and 4Cs, including A-A-B in Triple Science, she changed to a local FE college to study A Levels in Biology, Law, Psychology and Graphic Design. She has had sports and fitness related career aspirations in the past, wanting to be a gymnastics teacher and a physical training instructor in the Royal Air Force. Later on she was interested in being an architect or an interior designer and also paediatric nursing. Following her A Levels LemonOnion has said she probably wants to go to university to study Criminology and Sociology although sometimes she says she doesn't want to go to university and would prefer to get a job and earn money. Her interest in science has always been generally positive, but she has never exhibited any overt enthusiasm for the subject. LemonOnion appears to be quite laidback and pragmatic about science, seeing it as a means to an end for future careers in science or to be seen as 'smart' rather than because of any application to everyday life. She chose to take Triple Science because her school offered it to her and subsequently her mother encouraged her to take it.

SallyAnn, LemonOnion's mother, is an emotional literacy teacher at a special educational needs school and prior to this she worked as a medical receptionist in the NHS. She left school following her GCSEs and has spent a significant amount of her time caring for various people including her grandparents and her sons (LemonOnion's brothers) having separated from their father. SallyAnn has completed some further qualifications such as NVQs and a diploma and in retrospect would have liked to have attended university herself but that it simply wasn't on the radar for her at the time as no one mentioned it in her family, and she was expected to get a job

once she left school. As such she seems very keen for her daughters to have the opportunity to attend university but only if they are academically inclined. SallyAnn shows great interest in science throughout ASPIRES1 and ASPIRES2, and the illnesses of her elder sons gave her greater interest in and confidence in engaging with medical science in particular. She does watch science programmes and documentaries occasionally.

Social class indicator: SallyAnn is a single parent with 6 children living a small terraced house. This, and the type of job she has, suggests low levels of economic capital. Much like some other mothers in the sample, she has some cultural capital from her additional qualifications and work experience, deploying it to some extent when advising LemonOnion regarding her GCSE and A Level options. However, she admits much of her knowledge in this area is out of date and has felt frustrated regarding the secondary school LemonOnion attended and the lack of direction it gave her. Once again SallyAnn tried to organise work experience for her daughter through the school, as despite LemonOnion having several different interests, SallyAnn did not have the social connections to be able to source the placements herself.

Lucy

Lucy attended a mixed comprehensive in Leicestershire until the age of 18. Her GCSE grades were As and Bs, with C-C in Double Science. Since her GCSEs Lucy has chosen A Levels in Fine Art and English Literature because of enjoyment in the subject, and Psychology and they seemed 'interesting'. Lucy's initial interest in being a teacher became relegated to a secondary aspiration in years 8 and 9 when it was presented as a 'back up' career. Conversely, her consistent primary aspiration throughout the study was that of a fashion designer but Lucy appears to be mindful that teaching was a necessary 'plan b' and even considered studying psychology at university. Despite being in the top set for science, Lucy chose to do Double Science rather than Triple because of concerns that Triple would be too hard. She has had fairly consistent views on science at school throughout both ASPIRES1 & ASPIRES2, reporting that she didn't enjoy the writing aspect and had looked forward to the excitement of practical experiments in secondary school – which didn't quite live up to her expectations. Similarly, beyond some initial 'messing about' with science when she was very young, Lucy did not report engaging with science at home throughout the remainder of ASPIRES1 and ASPIRES2.

Lucy's mother, **Florence**, left school at 16 and currently works as a customer advisor. She is separated from Lucy's father and living with Lucy and her younger brother. As with many other parents she expresses her aspirations for Lucy to be happy and have a reasonably paying, secure job that she enjoys. She does not express an interest in science in ASPIRES1 or ASPIRES2, describing it as boring and irrelevant for her. Equally, she does not discuss engaging in science activities, either on her own or with Lucy.

Social class indicator: Florence owns her house, but currently has to pay for the mortgage by herself on a relatively low-paid salary and is considering selling the house in order to release some money and to set aside some funds for Lucy to go to university. As with several of the other parents, she does not demonstrate any significant cultural capital when discussing giving advice to Lucy about her educational choices and career prospects. Florence did not organise for Lucy to take part in a work experience placement and has not indicated she knows anyone socially who could support Lucy's aspirations, indicating low levels of social capital.

MacTavish

MacTavish attended a mixed comprehensive until the age of 16, where he GCSE grades are unknown. He left his school to work as an apprentice landscaper. MacTavish's aspirations have become more vague throughout ASPIRES1 and ASPIRES2. Initially he wanted to be a footballer, a policeman or work in IT but since year 9 he has articulated he would like to keep his options open and simply go for something that pays well and is interesting. Likewise, he wasn't sure what he would like to do after he leaves school, he would like to go to university to perhaps study geography but is concerned regarding the financial obstacles. MacTavish comes across as fairly pragmatic and is very focussed on what he is doing now, trying not to worry about decisions too far in the future. As such he is hesitant to pin down one particular career but rather areas, such as sports, travelling, etc. This has changed from earlier aspirations such as being a footballer or a policeman. MacTavish has had consistently good views of science throughout ASPIRES1 and ASPIRES2, saying his grades increased and that he could see that there were applications of bits of all sciences in many jobs. Despite expressing in year 9 that he would take Triple Science because he was in the top set and it made sense as it was the 'best one to take', he finally chose to do double award science because he was advised by teachers that triple was difficult and it would take up lots of his timetable.

Marigold is a single mother, having separated from MacTavish's dad, and works as a 'meals on wheels' lady. She left school at 16 and hasn't completed any qualifications since then – in fact she is extremely self-deprecating and doesn't seem to think herself as intelligent. She is extremely proud of MacTavish, who is a single child, and is confident that he will make the right decisions regarding his future. Marigold is also very protective of her son and wouldn't encourage him to attempt a course or a career that is very competitive because of potential disappointment. She has a positive view of science, but because she doesn't see herself as clever enough to understand it she doesn't engage with science a great deal.

Social class indicator: Marigold is a single mother and the nature of her job as well as comments by both her and MacTavish about not struggling for money suggest low levels of economic capital. Much like many of the parents in my sample, Marigold is very supportive of MacTavish and his schooling, but she lacks the cultural capital

needed to advise him in his subject choices. Again, when it came to his work experience, despite his interest in sports his mother obtained him a placement in a local mechanics as she knew the owner. This suggests that they have low levels of social capital with exchange-value.

Millie

Millie attended a mixed comprehensive until the age of 16 where her GCSE grades are unknown. After this she left to take a BTEC in Sports Science at a local college. She is extremely keen on sports and aspires to be a sports teacher, having cited her own PE teacher as a particular inspiration. Prior to this she wanted to be a primary school teacher for a long time and also liked the idea of being an actor or TV presenter, but Millie eventually dismissed this idea because of the competitive nature of the field. She would like to go to university to study a sport science degree followed by the teaching qualification rather than combining sports and teaching all the way through. Millie has been very enthusiastic about science, particularly the practical aspects of science throughout ASPIRES1 and ASPIRES2. However, throughout both the studies she has exhibited a lack of confidence in her ability and this dissuaded her from choosing Triple Science as her GCSE option and Biology at A Level, despite saying she felt it could have supported and complemented her sports science studies.

Sinead, Millie's mother, lives with her husband and all three children, including her married son with his wife and child. She works as a teaching assistant, having worked at a local supermarket as a retail assistant previously. Her husband has a removal service and works markets at the weekend. They both left school at 16 and Sinead has completed an NVQ in ICT since then. She has had strong feelings about Millie's schooling and is not happy with the teaching she has received in secondary school. Sinead is quite traditional regarding her expectations of school and the curriculum taught and has expressed disappointment that Millie has chosen to do a BTEC rather than A Levels. She says she took some time to come to terms with it but is adamant that Millie will go to university. Sinead has positive views of science; she watches science documentaries with her husband and the rest of the family and frequently reads scientific papers and articles on a range of topics. In ASPIRES1 she describes herself as not having the head for science and therefore states she is not interested in knowing the 'nitty-gritty' but rather the basics of what is happening, why and how this affects us. In ASPIRES2 Sinead says she would have liked to have been a scientific researcher but would have no idea how to get into that field.

Social class indicator: Sinead and her family moved from London to Norfolk and describes how you can't 'hustle' to make money in the new area. Her and her husband's jobs also suggest that they have low levels of economic capital. Sinead seems to have a notable amount of cultural capital in the form of science capital, talking about the journal articles she reads on a variety of subjects. However, once again she is limited in the advice she can give to Millie with regard to her subject

choices and admits to being unsure about various different GCSE options. Millie wasn't able to take work experience but she does report a limit to the number of people she could draw upon in her family with regards to different careers. Sinead states that she did a poll of her friends and family to find out if anyone knew someone working in science and none of them did, suggesting low levels of social capital.

Appendix 3: Year 11 interview schedules and questions of interest

Student interview schedule (particular questions of interest highlighted)

<div align="center">

ASPIRES 2 Pupil Interview Schedule (year 11)
</div>

Interview Briefing

- *(Re)-introduce self and the project (investigating how students' attitudes and views change over time) and remind them of year 6 and year 8 and year 9 interviews.*
- *Remind them about the microphone (ask permission/ensure that they are still comfortable with recording), and that someone will type the interview up but all the names will be changed. Remind them of their pseudonym if they picked it themselves. Say student's real name on tape at beginning and use throughout*
- *Remind them that everything they say remains* **anonymous** *and that teachers and parents won't be told about any of it (same as last time).*
- *Remind them that all the research will be written up and published (and that some already has been in articles and exciting conference presentations) and will be used to make science teaching more interesting.*
- *Make clear they know they do not have to answer all questions and that they can stop at any time if they wish, and that they can ask questions at any time throughout the interview. Also, that if they change their mind later on about their interview being used, they can tell their teacher or parent.*

Opening Questions

1. As you might remember, we spoke two years ago (or you spoke to relevant member of ASPIRES team two years ago). How have things been going since then/so far this year?

2. Any changes at home? **CONFIRM PARENT OCCUPATION (get more detail if possible)**

Identity

Construction of self – general

1. What kinds of things do you enjoy doing these days? (In and out of school – probe what student likes about these).

2. Any changes since last time we spoke (in the last two years) (new hobbies/interests)?

Construction of self – as learner

1. What do you enjoy about school this year, so far? (may have answered this already; prompt school subjects if not mentioned spontaneously)

2. What do you not enjoy about school?

3. Any changes since (year 6/8/9/we last spoke/you spoke with my colleague) in the subjects you like/dislike?

4. Any changes since (year 6/8/9/ we last spoke/you spoke with my colleague) in your marks? How about your behaviour?

Construction of self – as gendered subject

1. Would you say you're similar or different to the other girls/boys you know?
   If similar - in what ways are you similar? (Prompt: enjoy similar things?) Are there any ways in which you're different?
   If different - in what ways are you different? (Like different things?)

2. What makes someone popular in your school? Would people describe you as popular? Why or why not?

3. Do you care what your classmates think about you? How much? In what way? Does this affect the way you interact with others at school? How has this changed since you were in year 6/8/9?

Aspirations and the Future

Articulated aspirations and imagined/desired futures

1. What do you think you would like to be when you're older? What makes you think that? (Probe reasons, any other things you might want to be?)

2. How has that changed or not changed since we last spoke (over the past two years)? Prompt with what they said before-Why do you think what you want to be has changed/stayed the same?

3. Thinking about your main (current) aspiration(s): (N.B. if their aspiration hasn't changed, don't really need to probe much re where it came from – 'remind me…')

   a. How did you find out about that job? (Where did your ideas about that come from? Media etc.)

   b. Do you know anyone who does that job? (Probe if something seen on TV or learnt about in school or not etc.)

4. What path would you need to take to get a job like that? (Prompt: What steps do you need to take between now and then to get that kind of job; A-levels, university? What subjects would you need to take?)

5. How likely do you think it is that you'll be able to become (what they've said they wanted to be)? Why (why not)?

6. Is there anything that you think your parents would like you to be when you are older?

7. Do you talk about your ideas for the future with your family? (Probe – who, why/not, how often - is it an everyday/frequent/regular thing or quite rare?)

8. Is there anyone that you look up to/ would like to be like in the future? (can be personally known or unknown – e.g. TV personality) – why?

9. If you wanted advice or information about your future, where would you get it from or who would you talk to? (prompts: internet, family, friends, TV)

Subject Choices
Year 11 Options
1. What science option are you currently taking (Double/Triple/Applied or Some Other science, BTEC)? Was this your decision? If your school decides, do you know how this decision is made? Were you happy, or not, with this decision? (Why?) If you, your parents, or your teachers chose this option, why (not allowed to, marks, too difficult, lack of interest, not useful?). What options are you doing this year? Why did you choose those?

2. Have you decided what to do after GCSE? (If A-levels, which ones? Why those? (Interest/enjoyment; usefulness; attainment? Try contrasting them – e.g. if there were a subject that you really enjoyed but it wasn't very useful, what would you do?) If apprenticeship, work etc., in what area?)

3. Who did you talk with in making your decision? (Parents? Friends? Teachers? Careers advisors?) Whose opinion (besides yours!) matters the most in making your decision? (Parents? Other family members? Teachers? Careers advisors? Friends?)

4. (IF they say subjects outside the sciences) Why did you decide to study_____ (English/History, etc.)

5. (If not addressed already) What are you planning to do after age 18? (Why this? How decided?) If HE: Why? What do you think you might study? Why? How confident/not are you that you can achieve this?

Careers Education
1. Have you met with a careers advisor yet or had any careers talks/meetings? If so, was it useful? (Why/why not?) (If haven't met with an advisor yet, do you know when that happens?) How could this experience have been improved (prompt timing, frequency, group verses individual sessions, wider array of topics discussed)?

2. Have you had any workplace experience? If so, who organised it (school, parents, family friends)? Was it useful? (Why or why not?)

Science (and Other Subjects)
Achievement and Engagement in School Science
1. Is there anything you enjoy (or do not enjoy) about science at school this year? Has this changed from two years ago (or previous years)? Have your efforts or marks in science changed? (Probe which areas they enjoy more/less, biology, chemistry, physics).

2. Are there any areas of science that you're better at than others? (E.g. are you better at physics than at biology?)

3. Is there anything that encourages you to continue with science after GCSEs (teachers, practical/laboratory work)?

4. In terms of jobs, do you think the three sciences (Biology, Chemistry, Physics) are all equally useful? Or are some of them more useful or less useful than others? What

about engineering? Is that useful, or not? (If yes, how/why?)

Extracurricular Activities
1. Do you do any science (or science activities) outside of school? (E.g. read about science, visit science museums, watch TV programmes). Has this changed since over the past two years?

2. What about things like looking after pets? Nature walks? (Do you think of those as science activities? Why/why not?)

3. What about science clubs (afterschool/lunchtime)? Does your school have a STEM club? Do you go? How often? Do you enjoy it? In what way do you think you benefit through participating?

4. Do you do any other STEM/Science activities outside of school?

5. Why/not? Do you do any activities related to other subjects (such as English or history) outside of lessons?

Science over Time
1. Has your interest in science changed over the past two years? How has it changed (or not)? Do you like it more or less? Why? (If less interested, is it that science has become less interesting, or that other subjects have become MORE interesting?)

2. What about science lessons – can you tell me about how they've changed as you've gone from year 9 into year 11 (now at GSCE compared to when you started secondary school or in year 7/8, more/less difficult)?

3. What about your interest in other subjects – are there subjects that you see as related to science? (Probe: Maths? D&T?)

4. At GCSE, all students have to study science. Why do you think it is part of the curriculum in the UK, and that you have to study it?

(Science) Choices
1. You said you are currently taking double/triple/applied/some other science at GCSE. What about A-level – do you think you will continue with science? If so, which sciences do you think you will take? (All of them?) Why? (This might have been covered above)

2. Do you think it is more useful to be really specialised, or to take as wide a range of subjects as possible? Why?

3. What might put you off studying science at A-level? (Probe: Boring lessons? Topics? Doing poorly in the subject? Difficulty?) What about Maths? Technology?

(Science) Identities
1. At your school, what kinds of people are really into science? (What are they like?) What about Maths, Technology and/or Engineering? (What kinds of people are into these subjects? Similar to those who are into science, or not?)

2. Are any of your friends really into science? (What are they like?) What about Maths? Technology? Engineering?

3. Some people seem to think you have to be really clever to be in to science. In your experience, would you support that idea, or not? Is this different for Maths, Technology or Engineering?

4. At some schools, kids who are really into science are thought of as kind of 'geeky' – do they have that image at this school? (What kind of image do they have?) Can someone be really into science and still be popular? (For all sub-questions here-Is this different for Math, Technology, or Engineering?)

5. What about people who are really into English? What are they like? (What kind of image do they have?) Can someone be really into English and still be popular?

Relevance for Future Work
1. Is it useful to study science? Why/not? What sorts of jobs does it lead to? Are some sciences more or less useful than others? (Probe phys/ biol/ chem.)

2. What about Maths – useful to study? How well do you do in Maths? Do you like it? What sorts of jobs does it lead to?

3. What about English – is it useful? What sorts of jobs does it lead to?

4. Do you know what an Engineer does in their work? Do you talk about Engineering in any of your classes at school? At home with your parents (probe TV programmes)?

5. How would you feel about – becoming a scientist? (May have covered this already... having a job that uses some science?)

Women in Physics
We just have a few more questions specifically relating to Physics and the types of people who pursue careers in Physics.

1. Do you think there is anything that is putting women off pursuing careers in Physics? Why do you think that is? What about Engineering?

2. Some people suggest that girls who are particularly "girly" and super-feminine are less likely to want to pursue Physics. Do you think that could be the case? Why?

3. Is there anything else that you think puts people off Physics generally (for males and females)?

Concluding Questions
1. You may have seen on the news that the government wants more young people to study science after the age of 16, and to go into science-related careers. What do you think of this idea? What about Engineering/Maths/Technology?

2. What do YOU think would encourage more people of your age to do this? (i.e. to study science post-16 and/or go into science –related careers) (ask question for Maths, Engineering, and Technology too)

Parent interview schedule (particular questions of interest highlighted)

ASPIRES 2 Parent Interview Schedule (year 11)

Interview Briefing
- *(Re)-introduce self and the project (investigating changing aspirations of students) and remind them of year 6 and year 8 and year 9 interviews.*
- *Remind them about the microphone (ask permission/ensure that they are still comfortable with recording), and that someone will type the interview up but all the names will be changed. Remind them of their **pseudonym** if they picked it themselves and say parent's name on tape at beginning and throughout.*
- *Remind them that everything they say remains **anonymous** and that teachers and students/children won't be told about any of it (same as last time).*
- *Remind them that all the research will be written up and published (and that some already has been in articles and exciting conference presentations) and will be used to inform science education policy.*
- *Make clear they know they do not have to answer all questions and that they can stop at any time if they wish, and that they can ask questions at any time throughout the interview. Also, that if they change their mind later on about their interview being used, they can get in touch with us at beatrice.willis@kcl.ac.uk which is on the information sheet that was posted to them.*

Secondary School
1. How would you describe their time in secondary school?

   a. Is (child's name) happy? Do they enjoy school or not – reasons?

   b. Are you happy with their schooling, or not? (Reasons?)

   c. How would you describe their teachers? How would you describe (child's name) relationship with their teachers?

   d. How would you describe their friends? (Prompt: similar/different backgrounds? Similar levels of achievement, or not? Similar interests, or not?). Has this changed over the last two years, or not?

2. How is (child's name) doing academically? (Prompt: In science? How does this compare to other subjects?)

3. Are you satisfied with how son/daughter is doing at school? (Probe in relation to different subjects). Do you have any concerns?

4. What science option is your child taking this year? (Double, Triple, Applied, Some Other ie. BTEC).

   a. Who made this decision (school, parent, teacher, child)?
   b. How was this decision made (marks, awareness of university requirements etc.)?
   c. Are you happy with this?
   d. Do you think your child is happy with this?

5. Do you yet know what your child will do after GCSE? (e.g. A-Levels, apprenticeship, work etc. if A-levels which ones, or if work/apprenticeship, in what)?
   a. What do you think of those choices?
   b. How did they come to make those choices? (Probe: Parental role, role of teachers/school in those decisions).
   c. What factors do you think are important when choosing options?

Parent Involvement in Child's Education
1. How would you describe your involvement in your child/ren's education and schooling? (Prompt: in what ways would describe yourself as 'hands on' or 'hands off'). Probe: attendance at parents' evenings; how often in contact with teachers; any PTA or governors etc. involvement; help (monitoring of) homework, etc.) How has this changed over the years?

2. When was the last conversation that you had with (child's name) about school? How often do you talk about school? What are the most frequent topics / what sorts of things would you talk about on a typical day?) If not, what sorts of things do you talk about?

3. Do you encourage them to do any additional (e.g. after school/ weekend) activities? (Probe what and why)?

4. Does their school have a STEM club? Does (child's name) go? How often? Do they enjoy it? In what way do you think they benefit through participating? Have they participated in any other STEM/Science activities outside of school?

Target Child
1. (If not covered already), how would you say that (child's name) has changed or not changed since the last time (we spoke /you spoke with my colleague)? (Personality? Relationships with friends/siblings?)

2. What sorts of things do they like to do these days? (In general/ in their spare time?) Is this different from when (we spoke before/you spoke with my colleague) when they were in year 9)?

3. What are they particularly interested in or keen on these days? (Probe where this interest comes from (family background/friends/media); how often and in what way they pursue this interest and how (if at all) parents support that interest).

4. What is it about that that makes it interesting to your child?

5. As a family, what sorts of things do you do on a typical weekend (if anything) together?

Aspirations for Future: Parental
1. What would you like to see him/her do after he/she leaves school? (University? Work?) Why would you like to see them do that?

2. What do you think is the likelihood of him/her following that route at 18? (Probe: What might the barriers be to following this 'preferred' (whichever is preferred by the parent) route?

3. Do you have any particular hopes or aspirations for (child's name)'s future? E.g. fifteen years from now, what can you imagine him/her to be doing? (Prompt: Any particular jobs that you would like or not like them to do or not do? – Reasons? What about beyond work, general life aspirations i.e. work/life balance, volunteer work?)

4. Given that you know your child best, do you have an idea of any jobs that you think might particularly suit your child?

Careers Education
1. What career support have they received?

2. Do you feel your child's school has provided adequate career support for your child? In terms of educating them about what careers can come from taking certain subjects, what options to take at GSCE and A-level, as well as being informed regarding the more vocational routes? Do you think these provisions would have been more effective if they were introduced earlier in your child's education?

3. Has your child's participated in any career talks or work placements/experience? What subject were these in? Were they arranged by the school? If not, how were they organised (family connections, colleagues etc.)? Where they useful? How could they have been improved?

4. How involved have you been in providing your child with careers information/support resources? Are/is there any careers information/support resources that you have used or would like to help you better support your child?

Aspirations for the Future: Child
1. What does (child's name) want to be when they grow up? (Why/ where does that idea come from? (could prompt here with school, media, friends, role model) How do you know – is it something you have discussed with them? How likely is it that they might be able to achieve this?)

2. What would they need to do to be able to achieve this? (Probe – what subjects would they need to study? Would they need to go to university?)

3. What do you think of your child's ideas? (Agree? Supportive of them? Unrealistic? – probe reasons)

4. Has what they want to be changed over time? In what way? (If necessary, prompt with what they and their child wanted to be in previous interviews) What do you think the reasons for these changes might be? (Or why do you think they've stuck with a particular aspiration.)

5. If you do talk with (child's name) about the future/their aspirations, can you describe what these discussions are like – e.g. who initiates them? Who takes part in the discussion – other family members' involvement? Frequency? Etc.).

6. Do you have any concerns about their future?

Parents' Science Interests

We are particularly interested in parents' and children's views of science, so I have some questions now specifically about this.

1. Has your interest in science, technology, engineering, or maths changed at all over the last two years? (probe any science-related activities or connections, e.g. watch science/ nature programmes on TV, read science books/ magazines; go to science/natural history museum; gardening; know anyone with a science-related job?)

2. Is there a particular area of science, technology, engineering, or maths that you are more or less interested in than others?

Students' Science Interests

1. Now that they are in their final year of compulsory education (GCSE), would you say that (child's name) is interested in science or not? (Reasons why they think this). Probe any activities, TV, books, teachers etc.? Has this changed over the last couple of years?

2. How does (child's name) get on in their science classes at school? (probe reasons) Are there any sciences or areas of science that your child is especially interested in (Biology, Chemistry, Physics)? Any that he/she does particularly well in? (Explore any discrepancies between home and school interest in science, if relevant)

3. Are there any subjects that you feel it is particularly important that (child's name) does well in? (Probe ranking of science in relation to other subjects). If they have said child would do A-levels – what subjects would you like to see (child's name) do at A-level? Why? If science – any sciences in particular? (Which ones?)

4. What subjects do you think are particularly useful for your child to study (in terms of kinds of jobs they can lead to)?

5. Do you think (child's name) would ever consider a career that involves science? (Why/not?) Check for separate sciences – What about Biology? Chemistry? Physics? What do you think about this? (Probe reasons/ extent to which see un/desirable; im/possible?) What about engineering?

6. (If hasn't come through already) – Do you think working in a science-related job would suit (child), or not? Why?

7. We spoke last time about the idea that some people suggest that the 'geeky image' of science and scientists is something that puts students off pursuing science careers (or studying it after 16). But then others think that now there's this 'geek chic' sort of image to science, which makes it cool. Could you talk about what you think about this, specifically, do you think this is any different for young people your child's age, in year 11, compared to younger students, say in year 6/9?

8. Do you think your child's peer group influences their interests in pursuing science careers? Or non-science careers?

9. Do you think that being a boy or a girl makes a difference to science interest among

students your child's age? To the likelihood of pursuing scientific careers? (Reasons?) Does it vary depending on which area of science (Biology, Chemistry, Physics)? What about engineering?

10. We've been talking a lot about science, but what about Maths? How well does your child do in Maths? Is Maths relevant for future careers, useful at all?

Women in Physics

We just have a few more questions specifically relating to Physics and the types of people who pursue careers in Physics.

1. Do you think there is anything that puts women off pursuing careers in Physics and Engineering? Why do you think that is?

2. Some people suggest that girls who are particularly "girly" and super-feminine are less likely to want to pursue Physics. Do you think that could be the case? Is there anything else that you think puts people off Physics generally (for males and females)?

Closing Question

1. What would you like to see government, higher education, schools or other organisations doing to better support young people in their education and career choices?

Background/family context

The last time we spoke was when your child was in year 9.

Check for changes/confirm as relevant:
1. Ethnic background incl. migration/ generational status for ME participants
2. Family structure (partner/ no. of children). Any changes?
3. Age
4. Occupations – own and partner
5. Educational background (Own schooling; credentials/ higher education?)
6. What level did you take science to? (Which sciences – Biology, Chemistry, Physics). What was your experience of School Science?
7. Do you own any TVs? How many? Cars?
8. What is the best way to get project related documents/newsletters/the final report to you?

Coding framework of analysis of students' approaches to out-of-school science engagement and general dispositions related to science outside of the science classroom

Category	Description
1. Type of out-of-school science engagement	The types of out-of-school science engagement students reported undertaking, including who they did it with and how often
Code	**Data Example**
1.1. Out-of-school science experiences	Danielle - *I've been to the space centre. The one in London it's really good, because you get to do things for yourself, like, um you get to like touch different things and move it and do things like that… I went with mum and my dad.* (year 6)
1.2. Consuming science-related media	Celina - *I watch documentaries but I don't have any science kits or anything… I watch how like cloning can either help a person… cos cloning is an example of like Dolly the sheep. And like people's views about it, if they agree or disagree.* (year 9)
1.3. Science club	Football Master - *At the minute we're making a model heart… And then December we're going to the University of Southampton to make all sorts of stuff there and then we're doing something else after Christmas.* (year 9)
Category	**Description**
2. Perspectives on out-of-school science engagement	Students' accounts of why they did or did not engage in out-of-school science activities
Code	**Data Example**
2.1. Science-related dispositions or preferences	MacTavish - *It's like how you learn about what things do what and if you put them together what they do and things like that. I don't really know, I just like science cos it's interesting.* (year 8)
2.2. Science as 'something fun to do'	Hedgehog - *Oh yeah, I had like science kits when I was little and that and just experimented because it was fun, yeah.* (year 9)
2.3. Science can make you sound clever	Lucy - *I don't really have many scientific kind of activities outside of school but it's quite cool being able to show off to people that don't know what I'm on about, it makes me sound really smart. I'm just like 'Right, well the particles there, they're… the strongest colour, they're not …' and people are just going 'Alright'.* (year 9)

2.4. My friends like science	Bobster - *I was quite into science at the time and I saw the sign for the technology and science club and I found out that a friend of mine had already gone and enjoyed it, so I sort of went along with him.* (year 9)
2.5. Science is 'for school'	Connie - *They have a science club you can go to.* I – *Okay… do you go to it?* Connie - *No… because… obviously that's during your break and lunches and… because we've already done five lessons I think that's our time to obviously do our own thing* (year 11)
2.6. 'Too grown up' for science	Hedgehog - *Well I just think I've grown out of (science kits) a bit now, yeah.* (year 9)

Category	Description
3. Non-science out-of-school activities	The types of non-science out-of-school activities participants reported undertaking

Code	Data Example
3.1. Hobbies	Lucy - *I'm in the rock band for … I can't remember, we've not got a name yet actually, but it's on tomorrow lunchtime and we'll be getting stuff together. And my guitar playing, I'm second… I'm considering just being a vocalist.* (year 9)
3.2. Participation in non-science academic/prestigious activities	Celina - *If we're feeling like energetic then we'll like go like out bus journeys, or go to like let's say Stratford or Galleons and do something productive.* I - *So what do you mean by 'productive'?* Celina - *I mean we just like go out … maybe we'll make a change to society… Cos I'm doing Duke of Edinburgh I have to do like work in society. So, um we were thinking of either going to a care home and volunteering or like volunteering in like shops or schools or community centres.* (year 11)

Category	Description
4. Science-related cultural capital	Indicators of science-related cultural capital with personal use-value or exchange-value in the science classroom

Code	Data Example
4.1. Use-value science capital	MacTavish - *I mean my dad is a mechanic, well, used to be and so he knows all about that and I've got this internal combustion engine, so I had to like build that and he was like 'Oh, that doesn't go there' I didn't really get it but after a while, I kind of knew a bit about it.* (year 9)
4.2. Canonical science-related cultural capital	I - *Do you ever read books about science?* Celina - *Sometimes, yeah, it just tells you like what experiments you can do to find out for yourself and like you can do a fair test.* (year 6)

Category	Description
5. Family perspectives on science	Students' accounts of their family's views about science and its involvement in their daily lives

Code	Data Example
5.1. Talking to others about science in everyday life	Millie - *My granddad he's, um, he was a science teacher in university or something… and we go to him sometimes when we want to learn about stars or something*. (year 6)
5.2. Science does not form a part of home life	LemonOnion - *Outside of science you never talk about science, so it doesn't really come into it*. (year 9)
5.3. Parental interest in science	Hedgehog - *Well, it's like my mum and my dad - my dad's a postman, so science doesn't really involve it, so they don't really think about it*. (year 9)

Category	Description
6. Student habitus interacting with the out-of-school science field	When gendered, classed or racialised dispositions appeared in discussions regarding out-of-school activities, hobbies and within family perspectives to science, including how 'other people like them' engage in science

Code	Data Example
6.1. Gender	Danielle - *Every year I ask (my brother) for a bath bomb-maker and he always buys me the wrong one, but never mind… I said a bath bomb one, so the first thing he got me, a perfume one… I think it's a soap-maker I got the second year*. (year 8)
6.2. Class	MacTavish - *The only person in my family that's like done anything sciencey with me is my auntie. But see now I don't care if my mum hasn't and stuff cos they look after me, they see me loads, I can't blame them for anything*. (year 8)
6.3. Intersectional habitus (class/race/gender)	Lucy - *I've seen like them little kits and I've never bought one actually, but I've looked around them and you make your own little… experiments. It comes with a like a small test tube and… you can make it fizz… I've not actually bought one… because, um, mum says 'you know you've got the money. I thought you wanted to save up for new earrings or something'*. (year 6)
6.4. Localised habitus	Lucy - *I've never really spoke to anyone else about their family and science*. (year 6)

Coding framework of analysis of parents' approaches to out-of-school science engagement and general dispositions related to science outside of the science classroom

Category	Description
1. Parental involvement in child's out-of-school science engagement	Parents' accounts of the nature of their involvement with their child's out-of-school science engagement, including shared participation in activities, facilitation of child's engagement or a more passive approach

Code	Data Example
1.1. Organising child's engagement in out-of-school science	Sandra - *We went to the Space Museum… there was one bit and even I remember doing it where you could lift cans up according to the weight you'd be in each planet, things like that. (Danielle) enjoyed that… And when she had to do space a couple of months back… we went and got the books out the library for her to do that, so she could do all the like the planets from it. She did it all herself.* (year 6)
1.2. Shared participation in child's activities	Larry - *Yeah, and we've got … you can get like you know little science kits from the shops and there's various experiments that you know you have to do. They supply everything and then you put the things together and (Hedgehog) likes doing the experiments at home that we done a few of them.* (year 6)
1.3. Encouraging but passive	Robyn - *You was trying to do something last summer wasn't you, involved a plastic bottle and…* Charlie - *Yeah, no we had to make like a cardboard thing and then we put like a bottle in it and then put mentos with vinegar and lemonade and it just and then we opened the top and it had all water come out and it looked like a volcano.* Robyn - *I leave all that to them and I just say make sure you do it outside.* (year 9)

Category	Description
2. Perspectives on out-of-school science	Descriptions of parents' perspectives on their child's out-of-school science engagement, including what value can be derived from participating in science activities at home and in non-formal settings

Code	Data Example
2.1. Personal interest in science	Shelly - *We try to … I mean we're always experimenting with things and … you know … the science of gravity, just … I suppose yeah … science of … bizarre or not … of something floating, sticking, or whatever … yeah, I suppose we're everyday science people, but on the outside well you wouldn't see it like that.* (year 9)

2.2. Supporting academic achievement	Sandra - *it's like extra homework. And her and a friend made their own solar system and… they folded bits of paper, so you could see the difference from the sun for each one. And they just did that themselves between them. I was quite impressed with them both. What you've both done this and you've not been asked? (Danielle) said no, we just thought we want to do it. We liked it.* (year 6)
2.3. For entertainment	Jane2 - *I tend to go to the Science Museum a lot, because I like it there because you can do stuff. Whereas the other museums are a bit more just looking, isn't it? And yeah, and I like it there. You get involved… so they like all that… and the two younger ones they like to get involved in it all. So, um, yeah we like going to there. I always go there at least once a year go to the Science Museum… I go with my friends as well and they take their kids… So yeah, make a day ... and, um, yeah, so they enjoy that as well. So (Dave) likes it there as well.* (year 9)

Category	Description
3. Parents' general views about science	Parents' accounts of their views regarding science more generally, including whether they see it as a subject relevant to themselves and if it is accessible outside of the classroom

Code	Data Example
3.1. Not clever enough for science	I - *Would you say that you are interested in science or engineering?* Marigold - *Um, I don't think I've got the brains to be to be honest with you.* (year 6)
3.2. Science is for school, not home	Jane2 - *Science for us… like I said it's not a thing that you see a lot obviously. It's something that you see at school really, I would say, so you know in my everyday life it's not a thing that's out there… obviously I'm involved in his science for his work and school, but… I wouldn't say it's a big thing in my life every day.* (year 9)
3.3. Science can explain things	SallyAnn - *I'm the type of person that likes to know why things are the way they are and why they do the things they do… And how certain things happen and why they happen, sort of, from that interest… and that's probably about as much to science as I get, to be honest – wanting to know.* (year 9)
3.4. Science for personal development and/or recognition	Sandra - *I said to (Danielle) 'I really want - Human Biology, I want to do it, and I'm going to go back and do it' just like for myself a bit of it. Because I'm fascinated by things like that, I don't know, it's just something I'm interested in and they'll say to me 'God, you know so much about anatomy'.* (year 9)

Category	Description
7. Science-related cultural capital	Indicators of parents' science-related cultural capital with personal use-value or exchange-value for their child to leverage in the science classroom. Also, indicators that parents don't consider themselves to hold science-related cultural capital for transmission to their child

Code	Data Example
7.1. Use-value science capital	SallyAnn - *So because obviously having (son) that had a lot of medical issues and having to do I sort of learnt a bit. And a bit like what you're saying that parents will say to your friends why. I'm a little bit like that with doctors. Why are you doing that? If you do that, what does that mean and what will that entail?* (year 6)
7.2. Canonical science-related cultural capital	Sinead - *I watch everything really, really everything. Like I was watching one the other night, an Iranian nuclear physicist, but it was all about free energy and it you know going on from the Nikola Tesla's theory sort of thing… So really anything that'll come up that's new that I haven't seen I tend to watch… You know because we don't, we won't tend to watch a lot of TV. We tend to watch more documentaries together and things like that.* (year 9)
7.3. Lacking the scientific knowledge to bring science into the home	Florence - *I don't have a vast knowledge of science and maybe that's why me and (Lucy) don't discuss science as much as other stuff cos I just really don't know a lot about it.* (year 6)

Category	Description
4. Parental habitus interacting with the out-of-school science field	When gendered, classed or racialised dispositions appeared in parents' discussions regarding out-of-school activities, hobbies and perspectives to science

Code	Data Example
4.1. Gender	Florence - *I know boys… cos they love messing about, making things... I bought (my son) a Horrible Science kit for a birthday where he can blow a volcano up… That's just what they like doing, messing about, making things and blow them up… Whereas (Lucy)'s not really ever been into that sort of thing.* (year 9)
4.2. Class	Martha - *Yes, very. I was just going up to ransack his bedroom and I just said to his dad, I said it's awful with my daughters I can go up and say 'Right that's rubbish, that's rubbish', but he collects and stores such random things … you know things that you wouldn't expect any child of his age to collect. He's got some beautiful shells. Yes, very um - a strange child.* (year 6)

Coding framework of analysis of students' accounts of their position within the school science field and general dispositions related to science in this context

Category	Description
1. Placement in school	Students' accounts of their position in school, particularly with reference to how they are placed in science and how this compares to their peers

Code	Data Example
1.1. Attainment	Celina - *Yeah. Like my targets are like a C, B … and I'm getting … sometimes I'm getting As and Cs. In Science I'm getting Cs.* (year 19)
1.2. Sets in subjects	Connie - *Because I think I'm not very good at Science because of like the sets, they know … the teachers know… if you're good or bad at it, so I don't think I'm that good at it, cos I'm in the bottom set… Well, I think all my friends, we're all in bottom set of Science, so at the moment, I think that we are okay with Science, but it's not our best subject.* (year 8)
1.3. Double or Triple Science	Dave - *All my friends seem to be taking Triple Science. It's only me who's not. Like that I get the train with… I think all of them apart from me and my other friend.* (year 11)

Category	Description
2. Views of science in school	Students' reported perspectives of science in the school setting, both positive and negative, including what it takes to be 'good' at science

Code	Data Example
2.1. Science is a favourite subject	Danielle - *I just love science, so I'm not embarrassed to say that Science is my best subject, my favourite subject. I don't find that embarrassing.* (year 11)
2.2. Scientific knowledge can help you in everyday life	Celina - *(Science) also like explains a lot, so it can help you find more ways to like improve your health or something cos you finally understand what's going on… You know about the chemical reactions in your everyday life, like you know about the acids and the alkalis that are literally like right in front of you as well, so it helps you like 'Wow this is like amazing' cos it's like right there.* (year 11)
2.3. Science is a 'talent'	Bobster - *I don't feel like you have to be clever to - sort of - like Science, but I don't know it feels like being a leading mind and a leading mind in science would - sort of - take a leading mind, so… yeah, I think it's something that you've either got or you haven't.* (year 11)
2.4. Science is for academic students	LemonOnion - *They're more of people who are more into school, more people who actually want to do science, want to learn. And they just are smart.* (year 9)

2.5. School science is difficult	Lucy - *Generally speaking, the amount we go through in a lesson - which might be why I'm finding it a bit more difficult... 'cos we do cover a lot within a lesson.* (year 11)
2.6. Science teaching can be boring	Hedgehog - *Sometimes like we have to read from the book and just answer questions and that, it can be a bit boring sometimes.* (year 8)
2.7. School science is irrelevant for everyday life	LemonOnion - *I think it's just it gets a lot more complicated and turns into things you don't need to know, and it's like I'm not really interested in. Cos at the back of your head you're just going 'I'm never going to use it, why do I need to learn it?'* (year 9)
2.8. Scientific knowledge can be used for social capital	Dave - *(Science) it's like a sort of like a conversation, it's like that thing that you can say do you know this and that? And science is like involved with everything.* (year 11)

Category	Description
3. Relationship with science teachers	Students' descriptions of the nature of their relationships with their science teachers, and how it affects their perception of their ability in science

Code	Data Example
3.1. Being rewarded for good behaviour	Millie - *But I think Science is going to... my teacher - where I sat before I talked a lot, but now our teacher's moved us and I'm getting along and my teacher's been saying if you carry on you will move up because you're good and you're well behaved.* (year 8)
3.2. Being good at science makes you a Teacher's Pet	MacTavish - *If you're really into Science… like in this school, you might get a bit of, you know, hassle like 'Oh, you know, Science' and all that, but it's mainly… if you like, people think you're a teacher's pet if you want to say, then they'll, you know, take the mick or something like that.* (year 9)
3.3. Teachers respect my science ability	Bobster – *Our (science) teachers respect us a lot more now and because we learn, we're supposed to be like the express group, we move on very quickly from subjects because we're supposed to learn very quickly, it's seen that we will, our teacher's a lot more happy to sort of talk to us as humans as such.* (year 9)

Category	Description
4. Views of choice of Double vs. Triple science	Students' accounts of their placement in Double Science or Triple Science GCSE pathways, including whether it was their choice and if this affected their self-concept in science

Code	Data Example
4.1. Triple Science is for the 'top' students	I - *Why did you decide to do Triple Science?* MacTavish - *Because I'm in top set and obviously that's the best one to take so I took that.*

		I - *Yeah, yeah, what makes it the best one to take do you think?* MacTavish - *I'm not really sure but obviously the top set students all took it… I think it was more that you didn't have a choice, it's just if you were in top set, you take that, if you were in… in lower sets then you take a different one.* (year 9)
4.2.	Resigned to placement in Double	Hedgehog - *Yeah Double Science.* I - *Double Science. And was that your decision or did the school decide what Science option you're taking?* Hedgehog - *The school decided.* I - *And do you know how that decision was made?* Hedgehog - *No I don't.* I - *No. Are there other students at the school taking Triple Science?* Hedgehog - *Yeah.* I - *Okay. And are you happy with taking Double Science?* Hedgehog – *Yeah, I'm fine with it… Accounting doesn't really come in the Science department. And if I can get a C in Science I'll be happy with that, because I just know it's a pass.* (year 11)
4.3.	Triple Science is too difficult	Celina - *I didn't know what Triple Science was about, and I don't think I could have handled it as well… Cos some of like the… smartest people in our year* *… do it… and they still find it hard. So if they find it hard, like imagine what - it would just be like twice as hard for me I guess.* (year 11)
4.4.	Double Science is the 'main' option	Connie - *In the school (Double is) like the main one you have to do if like even if you don't take it as an option. That's the main thing you have to do.* (year 11)
4.5.	Triple Science would take up a GCSE option	Danielle - *Like it wasn't, the option wasn't Double or Triple. The option was do you want to do Science as an option?* (year 11)
4.6.	Triple Science gives me an extra GCSE	Football Master *I didn't decide to do it, but they sent me a letter saying I could do it if I want and I wanted to do it because it's an extra GCSE and I really like science.* (year 9)
4.7.	Triple Science pushes me to work harder	LemonOnion - *I think if I was in the like Additional Science and things I don't think I'd have tried as hard. Because the people I'm with in my (Triple) science class, they're all like slightly smarter than me and I kind of sit next to them, and... they just help me with everything. And then when I get it and I'm helping them... and I've just understood it more. Whereas all the other classes I think I wouldn't have been pushed as much cos the work I hear from them guys is really easy, and the work we're doing I think I get pushed more, because we have to do it at a much quicker pace, much quicker.* (year 11)

Category	Description
5. Science-related cultural capital regarding science choices	Indicators of science-related cultural capital related to the exchange-value of scientific knowledge or qualifications in fields beyond the classroom - or otherwise
Code	**Data Example**
5.1. Symbolic knowledge about the transferability of science in other fields	Dave – *(Science) can get you jobs and help you with like improving some subjects and whatnot.* (year 9)
5.2. Science is only useful for scientists	LemonOnion - *I've decided it's got to be an optional subject because if you don't want to go into a science career it's not going to help you with your day to day life.* (year 11)

Category	Description
6. Influences on school choices	Students' reported and influences on science/school-related choices, including which sources of advice they sought or if they deliberately made decisions on their own.
Code	**Data Example**
6.1. Advised by parent	Charlie - *I spoke to my dad, but like the year below us has had more options. Like they can do Sociology, Psychology. There was like four that they added after our year, which was like if I'd had that in my year then things would be so much easier for me.* (year 11)
6.2. Advised by teacher	Dave - *I could talk to like teachers and stuff to see like what they would say to me. But um, I guess that's it really.* (year 9)
6.3. Advice from social network	Celina - *I talked to my form tutor about it, but mostly like just myself I guess. I was the one who chose them cos my mum wasn't there, so - I talked to my friends about it as well.* (year 11)
6.4. Making their own decisions	I - *Who did you talk to about making that decision about… doing those subjects?* MacTavish - *No one.* (year 11)

Category	Description
7. Aspirations	Students' reported science-related aspirations, overall career aspirations and intentions to continue studying science post-16
Code	**Data Example**
7.1. Science Aspirations	Danielle – *My dream job, my like dream job would be to be a marine biologist, but I'm not good enough at Biology now. I'm not good enough at Biology to do that… I also wanted to be like a scientist, like in like a stem cell like - you know like cancer kind of places. You know like when they try and find cures.* (year 11)
7.2. Career Aspirations	MacTavish - *I'd like work for Microsoft or be something in IT.*

	I - *Ah okay, and why do you think that might be?* MacTavish - *Well because I'm into gaming at the moment and my Xbox broke down and then my dad fixed it.* (year 6)
7.3. Post-16 science aspirations	Bobster - *I think I would continue with science... even if I don't use it in my job in the future, if I get a job, it would be just good to know these things about Science* (year 8)

Category	Description
8. Student habitus interacting with the school science field	When gendered, classed or racialised dispositions appeared in discussions regarding their position within and views of school science, including how 'other people like them' get on in science and how comfortable they feel in science more generally

Code	Data Example
8.1. Gender	I - *Do you think there's something that's putting women or girls off pursuing careers in Physics?* Connie - *I think... obviously every girl's stereotyped to want to do something with Beauty. Like that is every, that's what every girl wants to do... I think like it doesn't really matter what you are when you're older. I don't think - but I think most girls would go for Beauty.* (year 11)
8.2. Class	I - *Is there anything... that you personally think would encourage more people your age... to pursue studying science after the age of 16?* Hedgehog - *If they was to provide more like subjects at college. Cos at the minute the only real ones they do is Biology, Chemistry and Physics. Which if... ever since you were a kid, if that's what you've been doing your whole life some people might find that boring. But like if they... have like aviation wise and that, like the Physics - then yeah, I would have chose to do it.* (year 11)
8.3. Intersectional habitus (class/race/gender)	Danielle - *I think the only stereotype is when someone turns 'round and goes 'you're in set 1 (for science)?' That's the only time you get it. You don't get like 'oh I thought you'd be in bottom'. You just get 'you're in set 1?' Like a bit of shock. But that's off close friends, so...* I - *So you think there might be a difference between kind of girls and boys?* Danielle - *Yeah, I think there's a difference between girls as well. Like girls who wear a lot of make-up and hair and look fake they're supposed to be in set 5 for everything and the girls that wear glasses and have short hair and don't wear any make up are supposed to be in set 1, but that's not true because in most cases it's the other way around.* (year 11)

Coding framework of analysis of parents' interactions with child's school science field and general dispositions related to science in an educational and career context

Category	Description
1. Relationship with or views of school	Parents' involvement with school, including relationship with teachers and indicators of extent of their knowledge about their child's progress
Code	**Data Example**
1.1. Satisfied with teacher's reports of child's progress	Jane2 - *You kind of think well they're doing okay, you see the teachers, they're at this. You know they always say 'he's this far', if he's hit the target… so you just think oh that's fine. That's good, but obviously he's not higher in sets in some things, which he obviously needed pushing in, which that sort of thing… so he's kind of plodding along really and he'd be quite happy to do that and… you don't see much when they go secondary school do you? You're not involved like you are at the primary school, so you kind of think well okay they're saying that. That's fine, but obviously now I know.* (year 11)
1.2. Concerned but not actively involved	Marigold - *I probably wouldn't be able to help (MacTavish) with his homework to be honest. I'm not the brightest button in the box to be honest, but no just in the sense - well he doesn't tell me. He doesn't tell me that he's, what he's got or what he's doing. I try to get it out of him, but I go to all the parent/teacher meetings and they all say how wonderful he is and everything, but as far as that it's like trying to do my best.* (year 11)
1.3. Lacking detail of child's position within school	I - *do you know what option (Hedgehog's) taking for Science? Is it Double Science, Triple Science?* Larry - *Oh I don't know other than science, you'd have to ask him.* (year 11)
Category	**Description**
2. Values on subject-related choices	Parents reported values communicated to child on science/subject-related choices, including whether or not being academic is important, and whether the use-value of a subject is more important than its exchange-value
Code	**Data Example**
2.1. Choosing subjects with use-value	Robyn - *She's talked about taking Spanish and I talked her out of that and said I'd rather she took French and then someone else said to me no Spanish is better because more countries speak Spanish now. You know so I'm like oh right okay. In my day it was French.* (year 9)

2.2. Preferring academic subjects	Sinead - *Food tech is the only one we're going to argue the hell out of… she's not doing it. I'm not having it, and she needs a stronger subject… I want her to do something more academic.* (year 11)
2.3. Choice based on enjoyment	Larry - *Well, you know we sat down together… and had a discussion with (Hedgehog) with you know me and his mum and said you know what he preferred to do, because it's no good studying a subject and he's got no sort of interest in it, because his heart wouldn't be in it and then that would reflect badly on the grade, so obviously he had a big influence on what he wanted to study.* (year 9)
2.4. Choice based on ability	Jane2 - *I was more wanting to know how the teachers thought his ability is… You know and if it was a good idea for him to take that option and then he's going to do well in that option, rather than just taking it because he thinks he's going to or he likes it… I wanted to know their real opinion of him because… they obviously see how capable he is.* (year 9)
2.5. Employability	Robyn - *English and Maths, cos they're just two real curriculum subjects that they need to achieve a good… it's hard to get a job nowadays, but I think the better your qualifications are the more chance you stand.* (year 11)
2.6. Not pushing child into decisions	Shelly - *It sounds really horrible, but as a parent I can't pressurise my daughter into doing something… I'm not going to put pressure on her to do French because I think it's something that she should learn.* (year 9)
Category	**Description**
3. Science-related cultural capital	Indicators of science-related cultural capital related to the exchange-value of scientific knowledge or qualifications in fields beyond the classroom - or otherwise
Code	**Data Example**
3.1. Science as a 'core' subject for employers and future education	SallyAnn - *Maths, English and Science… I would class them as your foundation blocks. Whether that be further education or careers – a lot of people aren't really interested if you did really well in Dance if you're going to go and work in a solicitor's office. They're not really interested in Drama if you're going to be a policewoman.* (year 11)
3.2. Unaware of the exchange-value of science qualifications	I - *Does the labour market sort of place a value on science qualifications?* Shelly - *No.* I - *Like employers do you think?* Shelly - *No.* (year 9)

Category	Description
4. Parental habitus interacting with the school science field	When gendered, classed or racialised dispositions appeared in parents' discussions regarding their child's choices in school science, either for subject choice or future aspirations in that area

Code	Data Example
4.1. Gender	I - *Would you ever recommend a career in science or engineering to her?* Florence - *Probably not, cos I don't really know what kind of careers you can get in it. It is ignorant of me really, but I know my cousin's girl, she's gone to college… she's doing some kind of mechanics' course or something and then I said 'oh how you getting on in it, are you going to be a mechanic then when you leave?' She said 'no I'm going into second line engineering' but I haven't got a clue what it is. I said 'oh that's good then', yeah, but I haven't got a clue what it involves and I thought it was quite unusual for two girls to do*. (year 6)
4.2. Class	Martha – *The minute he had to choose a career it was architect… It's… the designing something, being smart and - I mean he's 13 years old and he polishes his shoes every day… He… definitely likes (the) professional image. We live in (area of local town) and I think he's heard the word 'chav'… Most of the children around here are like that. They wear track suits and… baseball caps. So yes, when my kids come out of the house they look completely different to the children that go to the other schools… But yes… I think he'd like to be a higher class… He doesn't want to be here for the rest of his life.* (year 9)
4.3. Intersectional habitus (class/race/gender)	Florence - *Mainly to be happy in whatever she chooses to do. I mean, if she turns 'round and says 'I don't want to go to university and… I want to go and work in a hairdressers', you know, that can still be a good career… I wouldn't force her and say 'no, no, no you've got to go to college' if she really doesn't want to. So as long as she's happy. But I'd like her to achieve a proper career, not just a job because I worry about it more with (Lucy) cos I do think it is harder for girls and women.* (year 6)