The Significance of Outside-school Factors in Science Education: The Role of Families on the Attitudes that Turkish Children in London have to Science

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Declaration

I, Tuba Gokpinar confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed.

28 May 2018

Abstract

The literature in science education highlights the potentially significant role of outside-school factors such as parents, cultural contexts and role models in influencing students' science participation. Because a substantial portion of students' science attitudes and inspirations develop within the context of their families, their cultural background and their daily lives, it is important to understand how outside-school factors affect students' formation and expansion of science capabilities. In addition, students from minority ethnic groups face unique challenges in their science participation where outside-school factors have been suggested to play a major role. Finally, there is growing concern and corresponding research interest in the UK on ethnic minority students' science participation, but most studies have focused on 'major' minority ethnic groups (e.g., Black African/Caribbean, Pakistani students) and paid limited attention to other groups.

This study investigates the role of outside-school factors in students' formation and expansion of science capabilities in the context of Turkish minority students and their parents living in London. The study uses data from one independent Turkish school and one maintained school with a large Turkish student population in London including semi-structured student (n=16), parent (n=11) and teacher and staff (n=7) interviews, student questionnaires both from the two schools in London (n=93) and five additional schools in Istanbul, Turkey (n=383) to provide an analysis of how outside-school factors influence students' science capability development.

Building on and linking Bourdieu's key concepts of habitus, cultural and social capital and field with Sen's capability approach, the study develops a two-stage model of students' science-related capability development. The findings suggest that the role of outside-school factors is twofold, first, in providing an initial set of science-related resources and then in conversion of these resources to science-related capabilities and functionings. Qualitative and quantitative analyses indicate that science-related capability development is a complex process driven by both structure and agency. Overall, the study advances our understanding of the mechanisms involved in formation and expansion of ethnic minority students' science-related capabilities by introducing a new theoretical framework and by providing empirically based insights.

Impact Statement

Knowledge and insights generated in this thesis provide several important benefits to science education scholarship, policymaking and education practice.

First, the thesis provides a new empirically based understanding of Turkish minority students' development of science attitudes and aspirations. According to the Migration Observatory at Oxford, as of 2015, the UK population was 13.5% foreign-born (up from 7% in 1993) with foreign-born people constituting 41% of inner London's population. Despite the growing concern in the UK on ethnic minority students' science participation and the rapidly changing immigrant profile in the UK, most studies have focused on a small number of ethnic groups (e.g., British Black African/Caribbean, Pakistani, Bangladeshi, Indian) and ignored other minority ethnic groups that represent a notable portion of today's British society. The thesis helps to fill this gap by focusing on the Turkish-speaking community in the UK which has a large population of between quarter and half a million people.

Secondly, the study makes a conceptual contribution to science education literature by combining Bourdieusian theory and Sen's capability approach in a new theoretical framework which is also flexible and practical in addressing potentially important policy questions about the role of outside-school factors in science education. The framework can help science educators clarify the distinction between outcomes (i.e., functionings) and the ability to achieve these outcomes (i.e., capabilities) related to science education. If the primary goal of science education is to produce a scientifically literate population who are knowledgeable and well-informed about science, then a focus on formation and expansion of science capabilities would be appropriate. However, if the goal is to generate the next generation of scientists and broadly support STEM careers, then a focus on transforming capabilities into actual functionings in terms of further education and career choices would be suitable.

Thirdly, the thesis highlights possible ways to support outside school factors with a particular focus on family. Both at a national policy level and within-school level, it seems possible that a greater alignment between within- and outside-school factors in encouraging students and parents to engage with science would help more students to develop science-related capabilities.

Based on the findings of this thesis, it seems possible that immigrant parents and in turn their children can benefit from a more out-of-school and proactive approach by schools or local communities in engaging them with science. These can be particularly useful if they take place within parents' and students' own familiar domains with familiar activities such as food, cooking, planting, etc. Additionally, findings of this study suggest that closer and personally connected role models have the real influence on ethnic minority students' science aspirations (rather than distant role models or celebrity scientists), thus, policies encouraging such interpersonal interactions can provide significant benefits in raising ethnic minority students' science aspirations.

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1 Chapter One: Introduction to study

1.1 Introduction and motivation

The choice of my thesis topic was influenced by a number of factors including my Turkish background and educational experience in science education in Turkey, my work experience as a science technician at an inner London school and my volunteer experience with Turkish immigrant children and their parents at a London-based charity.

1.1.1 Turkish parents in Turkey vs in the UK

Growing up in Turkey, which has a larger youth population than any of the 28 EU countries, and with 61% of the population under the age of 35, you have no choice but to listen to many stories and participate in lively discussions related to youth and the role of education, and observe parental involvement in education and students' career aspirations. My observations in Turkey included active involvement of many parents in their children's education regardless of their socio-economic status. This may be because parents in Turkey see education as a key to upward mobility, success and prosperity for their children. Because entrance to universities, some elite high schools and certain middle schools are all based on national examinations, many parents believe that their children can go to top universities and find excellent job opportunities if their children study hard for schoolwork and prepare well for these exams. Parents in Turkey are usually very concerned with their children's success in the national examinations (Aksit, 2007).

Although the education system in Turkey has many significant problems, and its performance in international studies comparing and evaluating education systems like PISA is not impressive (Turkey ranked 54th in science worldwide in the most recent ranking (PISA, 2015), my observation was the presence of one thing that many people agree on about the education system in Turkey: the education system, especially the national examinations, which is believed to provide equity of opportunity for many children. The national examinations at different stages are mostly perceived as fair and effective in placing students in the highly competitive and limited spaces at various educational institutions in Turkey. People also observe and see many success stories around them. It is not too surprising for a parent from a low or middle income background to see her neighbour's, friend's, or relative's child getting placed in a select high school with a scholarship, then win a top place at a prestigious Turkish university, and afterwards start a successful career. People also see in the media some of these success stories, like a student from a small village who is the son of a shepherd with no formal education ranking first nationwide by getting the best marks in a national exam overall, and getting placed in a top university in Turkey.

Overall, my impression was that many parents were quite enthusiastic and ambitious about their children's education in general, and for science education and science-related careers in particular. For example, there is a select group of public and private 'Science High Schools' across Turkey where entrance is again by national examination, boarding is the norm and parents pay no tuition fees. Students graduating from these high schools normally do exceptionally well due to a rigorous and intensive education and gain places in the very best universities. Many of the best students in the nation select to study medicine or engineering in university as these lead to highly prestigious and well-paid jobs in Turkey. Many parents strongly encourage their children to study hard to get admitted to these Science High Schools and later study medicine or engineering in the university.

Although my personal observation was that many parents in Turkey have great enthusiasm for their children's education in general, and for science in particular, since I moved to the UK in 2009, I haven't observed this same pattern among Turkish parents in the UK. My impression was that many Turkish parents in the UK compared to the ones in Turkey may not be sharing the same ambition and urgency for their children's education. As parents, they were, of course, concerned about their children's future and cared about their success and prosperity, but they did not exactly think that education is the main key for their success like parents in Turkey. Rather, their priority for their children were for them to gain a decent and well paid job, mostly through businesses like kebab shops, grocery stores, etc. So, the initial impression I had was that Turkish parents in Turkey and Turkish parents in the UK were quite different in their attitudes towards their children's education in general, and towards science and science education in particular. While these were of course my casual personal observations, they led me to think and explore these issues further.

1.1.2 My background

After doing well in the national examinations and getting placed in a prestigious high school in Istanbul, Turkey, I then got admission to Bogazici University which is the Oxbridge equivalent in Turkey. I studied science education because I really liked science (particularly chemistry), teaching, and education. It was a rigorous yet practical programme, including both strong theoretical foundations and training in education theory, pedagogy, science and science education but also practical elements like doing internships and brief teaching experience in various schools. After moving to London, I started working as a science technician at an inner London school with a large ethnic minority student population.

I noticed a huge variation in students' attitudes towards science who are in the same classes and who are being taught by the same teachers. No matter how successful a teacher is, some students just show very little interest to science. Therefore, I inferred that inside school factors can explain only part of the story regarding students' attainment and attitudes towards science and science education. Before working as a science technician, I was a research assistant for a London charity where I was mostly working on projects with Turkish minority children and their parents. While working on these projects, I realised the huge influence of outside-school factors, such as cultural and parental factors, on students' attitudes towards education and on their career aspirations. I started to think that regarding the study of science and pursuing science-based careers, students' attitudes may be more influenced by outside-school factors (e.g., parents, role models, cultural contexts) than within school factors (e.g., teachers, lectures). This is why I decided to systematically investigate the role of outside-school factors in students' formation and expansion of science capabilities in the context of Turkish minority students living in London in my PhD study.

1.2 Science outside the school and ethnic minority children

As mentioned in the previous section, my initial motivation for this research was primarily driven by personal experience and observations both in Turkey and in the UK. Having a Turkish background, and educational and work experience related to science in both countries was very helpful to conduct my study. They helped me better understand and critically reflect on Turkish minority student's science attitudes and participation, and the role of outside-school factors in generating and shaping them.

Previous research has highlighted the potentially significant role of outside-school factors such as parents, the extended family, friends, cultural values and daily activities and practices as important influences in forming students' science attitudes and participation (e.g., Dierking & Falk, 1994; Crowley et al., 2001; Archer et al. 2012). While school is the main setting in which the young people encounter science and their views of science are filtered through the lens and experiences of school science (DeWitt & Archer, 2015), yet students between the ages of 5 and 16 spend only around 18% of their sixteen waking hours per day in formal education (Bransford, 2006). Therefore, if we want to understand students' attitudes to the study of science in a comprehensive manner, we should pay close attention to the cultural contexts outside school in which students are situated and where their attitudes are largely produced (Osborne, 2007). However, despite their significance, with compare to studies in science education that focus on in-school factors, outside-school factors have received less attention. In their editorial for International Journal of Science Education, Osborne & Dillon (2007) attributed this partly to the difficulty of conducting research and gathering data in informal contexts which are noisy and unpredictable. As a result, they commented (p.1442): "The outcome is that while the study of learning science in formal contexts has at least reached the foothills of knowledge and understanding, researchers working in informal contexts are still in the plains gazing at the mountain in the far distance".

Outside-school factors are clearly important in students' formation and expansion of science attitudes and capabilities, but such factors could operate in unique ways for ethnic minority children. Indeed, such students may face unique challenges in their science participation where their ethnic background, immigrant identity, family and cultural contexts can affect the presence and influence of various outside-school factors (Archer et al., 2015; Jones & Elias 2005; Turney & Kato, 2009).

In addition, science participation among ethnic minority children is a growing concern in the UK with a surge in recent research interest (Wong 2015, 2016). However, most studies in this area have focused on ‘major’ minority ethnic groups such as British Black African/Caribbean, Pakistani, Bangladeshi, Indian or Chinese students, and paid limited attention to other groups. The immigrant profile in the UK is rapidly changing with Poland now being the most common foreign country of birth and foreign-born people constituting 41% of inner London’s population (Rienzo & Vargas-Silva, 2017). Yet, other minority ethnic groups which represent a notable portion of today’s British society did not receive sufficient research attention despite evident differences in their unique characteristics with also varying attitudes and participation rates in science (Elias & Jones, 2006). My study helps to fill this gap by focusing on the Turkish speaking community in the UK which involves mainland Turks, Kurdish Turks and Cypriot Turks with a large population of between 250,000 (Düvell, 2010) and half a million (Travis, 2011) people.

1.2.1 Overview of the contributions made by this study

With my study, I hope to provide the following four contributions to science education literature. First, I believe the role of outside-school factors in shaping and developing students’ attitudes, capabilities and aspirations in science is an under-researched area. From cultural factors to family dispositions (e.g., religion, ethnicity, cultural activities) to outside-school activities done with parents (e.g., visiting museums) and from daily practices and specific parental actions (e.g., buying a science-related toy) to role models in the extended family and friends network, outside-school factors could be highly influential on students’ attitudes towards science, and systematically studying these with a theoretical framework and empirical data is an important contribution to our understanding of such outside-school factors.

Secondly, although there is a large body of literature on ethnic minority students' educational attainment and aspirations in general, there is relatively less work specifically looking at science, and it is almost nonexistent about Turkish minority students. Thus, I believe my work is an important contribution to research in science and ethnic minority students in the context of Turkish immigrant children.

Thirdly, by conducting additional work in Turkey to compare students' science attitudes and aspirations in Turkey in comparison to Turkish minority children in the UK, I believe my study provides rich insights on the role of being children of immigrant parents in the UK and how the immigrant identity, dispositions and practices could help or inhibit students' science capabilities and science participation.

Finally, I hope that my work presents some practical recommendations and implications for science educators and policy makers in general, and for the Turkish immigrant community in the UK in particular. Because young people's education is suggested by many as the Turkish community's most important problem and challenge in the UK, I hope that my academic work provides some useful and practical recommendations on how to improve this situation in the context of science education.

1.3 Organization of the thesis

The thesis is organized into nine chapters, which consist of the following:

Chapter 2 introduces the research context, relevant terms, and literature. This section both defines the key terms in the thesis including science attitudes, participation, aspirations, outside-school factors, immigrant, and ethnic minority, and also provides an overview of the relevant literature on science participation, science aspirations, outside-school factors, and ethnic minority children. Along with the research overview, this section also highlights relevant policy concerns and discussions. The chapter then moves onto the specific context of Turkish community and Turkish minority children in the UK by providing a brief historical overview we well as present day issues. The chapter concludes by presenting the specific research questions that are investigated in the thesis.

Chapter 3 presents the theoretical foundations of the thesis by first presenting Bourdieu's key concepts of habitus, cultural and social capital, and field, and then Sen's capability approach. After discussing these two perspectives along with their relevance and use in education research, the chapter then introduces a new theoretical framework by synthesising Bourdieu (1977, 1993) and Sen (1992, 1993), and explain how outside-school factors can act both as an initial resource provider and then as a converter in students' development of science-related capabilities. It then provides details and workings of the two-stage model proposed in the thesis, discusses how the two perspectives of Bourdieu and Sen may complement and enrich each other, and critically engages with the existing literature to highlight the contributions of the model. Overall, this chapter addresses the first research question in the thesis "through which mechanisms do families, cultural contexts and other outside-school factors influence students' participation in science?".

Chapter 4 outlines the methodological perspective and research design. It starts with epistemological and ontological approach and discusses why a critical realist perspective is chosen. It then explains the mixed-methods approach employed in the thesis and discusses its suitability for the study. The chapter presents the sampling approach along with a description of data collection steps and research sites. Research methods employed in the study were then outlined, first in-class observations, followed by questionnaire/survey and then interviews. For each research method, theoretical and practical considerations as were as rationale for using the method were presented, contextual details were described, and finally, data analysis approach was outlined. The chapter concludes with a discussion of the ethical issues involved in carrying out the research and how they were addressed throughout the study.

Chapter 5 presents an illustrative case study of the theoretical framework outlined in Chapter 3 with an empirical data collected for this thesis. The case builds on the theoretical model and demonstrates the twofold role of parents and families both as a resource provider and then as a resource converter in science-related capability development. It also highlights and shows the benefits of Sen's distinction between capabilities and functionings in understanding the role of outside-school factors in students' science-related attitudes and aspirations. By comparing and contrasting three in-depth examples, Zeki, Derya, and Fulya, this chapter demonstrates how the theoretical model introduced in Chapter 5 can be useful to enrich our understanding of the role of outside-school factors in science education.

Chapter 6 draws upon the qualitative (interview) data from the two schools in London, Athenaeum and ANS, explores in detail the model of science-related capability and functioning development, and presents the findings in light of the theoretical model. This analysis chapter examines (i) initial resources, (ii) conversion factors from initial resources to capability development, and (iii) conversion factors from capabilities to functionings related to science in the context of Turkish minority children. The goal in this chapter is to empirically identify and examine critical factors that influence Turkish minority students' science-related capability and functioning development with a qualitative approach using children (n=16), parents (n=11) and teacher and staff (n=7) interviews. Overall, with a qualitative approach, this chapter addresses second and third research questions of the thesis, namely "What is the role of cultural contexts and parental factors (e.g., attitude, involvement, practices) in forming and expanding immigrant Turkish students' science capabilities?" and "What other outside-school factors promote or inhibit immigrant Turkish students' attitudes and aspiration in science and how?"

Chapter 7 also addresses the second and third research questions, but with a quantitative approach by analysing data collected through student questionnaires from the Athenaeum School (n=51) and the ANS School (n=42). Informed by the theoretical model in Chapter 3, and following the structure of Chapter 6, this chapter presents survey results on initial science-related resources, and then discusses findings on how science-related capabilities and functionings are developed, and associated factors driving capabilities and functionings. Because the two schools involved in the study, Athenaeum and ANS, differ significantly in terms of fees (ANS is free, Athenaeum is not), school size (ANS large, Athenaeum small), and student population (ANS is mixed with a significant Turkish student body, Athenaeum is almost entirely Turkish), these may have implications for students' science-related capability and functioning development. Consequently, this chapter also investigates differences between the two groups of students (Athenaeum versus ANS) in terms of their initial resources, their science-related capabilities, and science-related functionings.

Chapter 8 compares and discusses the quantitative findings from the survey with Turkish children in Turkey and Turkish immigrant children in the UK. With this analysis, the chapter addresses the fourth research question of the thesis which could be considered as a follow up to the previous research questions: “How are immigrant Turkish students similar or different in their science capability and functioning development compared to their counterparts in Turkey?” By comparing immigrant Turkish children with their non-immigrant counterparts, this chapter tries to provide a better understanding of the role of ‘being immigrant’ in students’ science-related capability and functioning development. During the interviews in Chapter 6, many immigrant Turkish parents provided detailed and vivid accounts and comparisons between their lives in the UK and their relatives and friends’ lives in Turkey, by highlighting potential advantages and disadvantages experienced by their children in science-related capability development compared to their counterparts in Turkey. This chapter explores such issues by drawing from the survey data in the two countries.

Chapter 9 brings together the findings of the thesis, connects results from the qualitative and quantitative analyses, and discusses the contributions of the study to knowledge in science education. In particular, the chapter highlights the theoretical contribution of the two-stage model proposed in the thesis and provides a summary and discussion of the research findings in relation to existing research. This chapter then provides five major recommendations for policy and practice before providing a detailed discussion of the limitations of the study and future research suggestions.

2 Chapter Two: Research context

This chapter introduces the research context of the thesis. I first introduce emerging issues, relevant research and policy discussions on students' science interest, participation, and aspirations. I then discuss the role and potential significance of outside-school factors in shaping and generating students' attitudes and aspirations in science, followed by a discussion of the research on ethnic minority children and science participation. Next, I present the specific context of Turkish community and Turkish minority children in the UK in terms of the population overview, historical background, socio-economic dynamics, and community, culture and social life. This is followed by a focus on recent educational concerns about Turkish minority children in the UK. Finally, following the outline of the presented research context, I introduce the research questions that will be addressed by this study.

2.1 Science, interest, participation, aspirations

Science matters for society for multiple reasons. Science, technology, engineering and mathematics (STEM) skills are critical to innovation and prosperity, and in creating a competitive advantage in knowledge-intensive economies such as the UK. In January 2017, the UK Government published a green paper on Industrial Strategy with an objective "to improve living standards and economic growth by increasing productivity and driving growth across the whole country" (BEIS Department, 2017, p.9). In order to achieve this objective, the document listed ten strategic pillars, of which, the first two were directly relevant to science and science education:

> 1. Investing in science, research and innovation—we must become a more innovative economy and do more to commercialise our world leading science base to drive growth across the UK.
>
> 2. Developing skills—we must help people and businesses to thrive by: ensuring everyone has the basic skills needed in a modern economy; building a new system of technical education to benefit the

> half of young people who do not go to university; boosting STEM (science, technology, engineering and maths) skills, digital skills and numeracy; and by raising skill levels in lagging areas. (p.11)

Science matters not only for economic prosperity; it also important for society in general to have sufficient knowledge and understanding to follow science and scientific debates as scientific issues become more important in our daily lives (Millar & Osborne, 1998). Regardless of their career aspirations or aptitudes, it is held that young people who grow up in contemporary societies should have the basic scientific literacy to make well-informed decisions on science-related matters that concern the wider public.

A major issue with regards to the current state of science in the UK is the lack of diversity in the scientific workforce. The Royal Society (2014) report on the UK scientific workforce states (p.7):

> A lack of diversity across the scientific community represents a large loss of potential talent to the UK. Restricted opportunity and diversity limits not only UK competitiveness and prosperity, but also vitality in the wider scientific workforce and creativity in society. Individuals from lower socioeconomic backgrounds, certain minority ethnic groups, women, and disabled people are all currently underrepresented in education, training and employment related to STEM.

Interest is defined by early education researchers as “being engaged, engrossed, or entirely taken up with some activity because of its recognized worth” (Dewey, 1979, p.160). Interest development, which begins early in the childhood within the family with play and learning, is critical for a child’s understanding, needs and future intellectual pursuits. In children’s participation in learning science, enthusiasm and personal interest have been suggested to be two key drivers (Jolly et al., 2004). Interest development, which is mostly stimulated in the home, is associated with future academic goals, achievement, and success (Hidi & Harackiewicz, 2000). Children start demonstrating an interest in science as early as primary school (Maltese & Tai, 2010), and by the time they are 13 or 14, students’ science interests may be largely formed (Lindahl, 2007; Bennett & Hogarth, 2009). These studies suggest that early years in the family are fundamentally important in generating science interest for children.

However, even early interest may disappear, as a number of studies have highlighted students' loss of interest to science by the time they are 15 (e.g. Osborne & Collins, 2001; Jenkins & Nelson, 2005). While a variety of reasons have been suggested for this loss of interest, a recent study by the Department for Business, Innovation and Skills (2014) used an innovative approach to understand young people's STEM perceptions by examining their real-time conversations on STEM on social media (i.e., Twitter). They found that in young people's conversations:

> STEM is perceived as being too difficult and complex; hence, young people fear STEM choices will lead to poor academic performance and they will end up with unachievable goals.
>
> STEM is perceived to involve a heavy workload and personal commitment. Young people believe that if they choose these types of subjects they will struggle and end with huge amounts of stress.
>
> STEM is socially uncool, it is associated with a 'lame lifestyle' to use the current language of teenagers. People going into STEM are perceived as 'uncool' and associated with a lack of social skills and a boring social life. Even the young people who are already engaged with STEM are self-conscious about being perceived as socially uncool or 'weird'.
>
> STEM subjects are perceived as too abstract and academic. Young people believe they are useless in real life and there is no point choosing them since they do not see how they will use or apply such abstract knowledge in the real world.

Such loss of interest for science by students and their lack of science participation is a major concern repeatedly highlighted internationally in research and policy communities (Roberts, 2002; DIUS, 2009; Osborne et al. 2009; Hodgen, Marks & Pepper, 2013; EU Skills Panaroma, 2014). This is because while knowledge-based economies increasingly rely on science and technology, and STEM skills are suggested to be pivotal in economic development, there is growing shortage of required STEM skills in the western world (EU Skills Panaroma, 2014).

Science participation is clearly linked to students' science aspirations. Aspiration has been defined as: "a student's ability to identify and set goals for the future, while being inspired in the present to work towards those goals" (Quaglia & Cobb, 1996, p.130). Aspirations are constructed in a highly contextual nature with strong family influence (Allen, 2013). Indeed, multiple studies that focus on students' science aspirations have pointed out the close connection between students' aspirations and family science attitudes (Keller & Whiston, 2008; DeWitt et al., 2011, 2013) or, more broadly, parents' science capital (Archer et al., 2012; Archer & DeWitt, 2017). Aspirations can also be strongly affected by structural limitations including class (Flouri & Panourgia, 2012; St Clair & Benjamin, 2011), gender (Francis, 2002; Gutman, Schoon & Sabates, 2012) and ethnicity (Strand & Winston, 2008).

It is also important to note that, previous research argued against the notion of blaming 'low aspirations' particularly in the context of ethnic minority students in that minority groups may already have high attitudes and aspirations, but it may be the surrounding conditions that are leading to low progression in science (Dewitt et al., 2011).

Overall, recent research and policy discussions highlighted several points on students' science interest, participation and aspirations (e.g., Archer et al. 2016; Archer et al. 2015, Archer & DeWitt, 2017; Department for Business, Innovation and Skills, 2014). These include the critical role of early childhood in developing science interests, concerns on many students' lack of science participation in the later years, and the role of family and contextual factors in influencing science aspirations. These issues will form the basis of my research questions in understanding Turkish immigrant students' science participation and the mechanisms associated with role of outside-school factors, particularly related to family and contextual factors in influencing this.

2.2 The role of outside-school factors

Outside-school factors can be considered as parents and their actions, role models in the extended family or friends' network, cultural contexts such as cultural values, daily activities and practices, and other out-of-school experiences. Out-of-school experiences can be defined as informal experiences that include a range of learning activities from daily activities found at home, such as discussions among family members and information received through the media, to recreational activities, such as gardening, hiking and visiting zoos, aquaria and museums (National Research Council, 2009). Students' out-of-school experiences might have a major impact on their science learning because these experiences provide opportunities for students to construct, modify and reflect on the content knowledge they gain in the classroom (Tran, 2011). When students are involved in science-related activities outside the school in a real, personal and relevant way, they typically experience much deeper and more meaningful science learning (Calabrese Barton, 1998; Fusco & Calabrese Barton, 2001; Rahm, 2002).

A large body of research suggests that families play an important role in influencing students' interest, engagement, aspirations, and attainment in science (Ferry et al., 2000; Gilmartin et al., 2006; Huang et al., 2000; Mujtaba & Reiss, 2014), and this relationship is subtle and complex (Atherton et al., 2009). Aschbacher, Li and Roth (2010) found that family socio-economic status and having family members in science-related careers have a significant impact on students' science experiences, science-related career plans and persistence in science. Parental attitudes and support is also highly influential on the formation of post-16 science-related choices (Cleaves, 2005; Gilbert & Calvert, 2003) and on career aspirations and academic development in science (Ferry et al., 2000; Reiss, 2004). This effect may depend on students' gender (Tenenbaum & Leaper, 2003), where parental encouragement and support can strongly influence girls' perception of science- and mathematics-related career choices as suitable for them (Turner et al., 2004). Archer et al. (2012, 2013) indicated that family resources, values and practices, i.e., 'science capital', that is, science-related forms of cultural and social capital (Bourdieu, 1986), have a significant influence on children's development of science aspirations. Similarly, DeWitt et al. (2011) found that children's perceptions of their parents' attitudes towards science have a strong relationship to the children's aspirations in science.

Because the relationship between family and students' interest and participation in science is subtle and complex (Atherton et al., 2009), and there is an intricate interplay between various outside-school factors and the science capital of students, in this thesis there is merit in identifying and exploring patterns of outside-school factors influencing students' science participation.

A major factor which influences students' science attitudes and aspirations is social class (Reay, David & Ball, 2005; Adamuti-Trache & Andres, 2008). Working-class children between the ages of 10-13 are found to be much less likely to have science career aspirations (Archer, Dewitt & Wong, 2013) than are middle-class children. Indeed, in the UK, a recent report by the Social Mobility Commission (2017, p.2) states the following:

> In today's Britain, where you start from has a big influence on where you end up. Indeed, for young people it seems that the link between demography and destiny is becoming stronger rather than weaker. The attainment gap between disadvantaged and better-off pupils, which starts in the early years, widens during a child's schooling with long-term, detrimental consequences for social mobility. Disadvantaged young people's options and outcomes lag behind their better-off peers and vary dramatically across the country. While 61 per cent of the latter cohort get two or more A-levels, this figure is just 36 per cent for disadvantaged youngsters.

Multiple studies in the UK have found significant evidence for the relationship between social class and science aspirations. Working-class girls and boys tend to associate science-careers with 'middle-class academic masculinity' (Archer, Dewitt, Osborne et al., 2013; Archer et al., 2014), discouraging them from aspiring in science. Class may also influence access to valuable out-of-school experiences (Dawson, 2014b). From a social-cultural perspective, contemporary science could easily be viewed as a white middle-class dominant subculture (Lemke, 2001), and those outside it, such as minority students, may feel left out and develop their own common codes and communications in science learning (Lee & Fradd, 1998; Rosebery et al., 1992). Most visitors to science museums in the US are middle-class white students and their parents (National Research Council, 2009). Even when they visit, working-class families may perceive exclusion from such informal science learning environments (Dawson, 2014b) or experience linguistic or cultural problems (Ash, 2004; Rahm, 2008) in these settings. Indeed, accessing and deriving benefits from outside-school resources and experiences is highly patterned by social class, with the middle classes using such resources to increase their use and exchange value whereas those who do not possess the dominant white middle-class cultural capital may face exclusion or even exploitation (Skeggs, 2004; Reay et al., 2007). After all, families' social position affects the resources available to them. In fact, not only class but also a related factor, where people live, has been highlighted in multiple studies in the UK as a key constraining factor for disadvantaged children to reach their potential. A strong link has been identified between the chances of people from disadvantaged background getting on in life and where they grow up and choose to make a life for themselves; a key finding in the recent index developed by the Social Mobility Commission (2017, p.1) is stated as follows: "A stark social mobility postcode lottery exists in Britain today, where the chances of being successful if you come from a disadvantaged background are linked to where you live".

In addition, in the UK, a large number of studies have pointed out the advantages held by the middle class whose familial habitus can generate 'the pursuit of advantage' (Reay, 2006), where the deeply internalised system of dispositions, perspectives and experiences shared by the family members could provide distinct advantages to middle-class children. This can take the form of families successfully combining economic, social or cultural capital for personal and educational enrichment of their children (Dika & Singh, 2002; Vincent & Ball, 2007), strategic choices made in the education market (Reay, David, & Ball, 2005) or greater promotion of academic achievement in the family (Perna & Titus, 2005; Sandefur et al., 2006). In addition, recent research has recognised and advanced the idea of scientific forms of social and cultural capital (i.e., science capital) which is institutionalised through knowledge, consumption, or networks and which can help families promote and expand children's science interests and aspirations (Archer et al., 2012; 2015). Such advantages can further contribute to personal well-being; more importantly, in Sen's (1993) terms they can help develop capabilities – the ability to do valuable acts or to reach valuable states of being.

Indeed, outside-school factors and their role in students' science capability development are not independent of structure. In fact, in developing a capability framework for human well-being, Sen (1985, pp.69-70) points out: "the quality of life a person enjoys is not merely a matter of what he or she achieves, but also of what options the person has had the opportunity to choose from". In providing options from which to choose, structure plays an important role in shaping or perhaps constraining the choice set available to individuals. Structure is also intertwined with individuals' experiences within the family (Calabrese Barton & Tan, 2009; Calabrese Barton et al., 2013). However, focusing too much on structural factors such as demographics or social position may lead to other dynamics that influence children's science participation being missed (Falk & Dierking, 2000; Carter & Fenton, 2010; Ulriksen, Madsen, & Holmegaard, 2010). Previous literature identifies highly patterned nature (based on structural factors such as gender, social class, and ethnic minority background) of students' science participation as an important concern; however, previous initiatives and attempts to break this pattern have provided limited benefits (e.g. Calabrese Barton & Tan, 2010; Daly et al., 2009; Smith, 2010; 2011).

In addressing the issue of unequal nature of children's science participation, a multifaceted perspective that simultaneously considers both structure and agency could be helpful. After all, while factors such as given social positions and family socio-economic and cultural resources are likely to have an influence on children's science participation and their development of science capabilities, they may not be the only and ultimate determining factors. If that is the case, we would not see varying degrees of science participation and science-related capability development for children from the same ethnic and social groups. This suggests that change as a result of agency could be possible despite its constrained nature with structure. Indeed, with his capability approach, Sen (1999, pp.11-12) provides a balanced perspective on the agency vs structure debate:

> The freedom of agency that we individually have is inescapably qualified and constrained by the social, political and economic opportunities that are available to us. There is a deep complementarity between individual agency and social arrangements. It is important to give simultaneous recognition to the centrality of individual freedom and to the force of social influences on the extent and reach of individual freedom.

That means, for science, that engaging and benefiting from outside-school experiences is patterned by social class, ethnicity and immigrant identity; yet the role of individual agency and change cannot be ignored. These dynamics in turn further complicate our understanding of the role of outside-school factors in science participation. As such, my thesis aims to explore these intricate relationships in an empirically informed way in the context of Turkish minority children. Indeed, by focusing on a one particular group, Turkish minority children in London, whose ethnicity, immigrant identities and even social positions and where they live are somewhat similar and more easily comparable, my research can provide new insights into explaining science participation and the role of agency in students' development of science capabilities.

2.3 Ethnic minority children and science

Ethnicity has also been suggested as a potentially significant element in influencing science outcomes (Huang et al., 2000; Riegle-Crumb, Moore & Ramos-Wada, 2011). For example, in the UK, some Asian students' high achievement and high interest in science is well documented (Abbas, 2004). For instance, Elias et al. (2006) reported notable differences in GCSE achievement by ethnic groups in the UK, with Chinese and Indian pupils performing better than any other group including white pupils. Students from Black Caribbean, Pakistani and Bangladeshi backgrounds, however, perform less well, and demonstrate significant attrition in chemistry and physics at this early stage. Similarly, in the USA, Gilmartin et al. (2006) found that family influence may work in different ways for different ethnic groups, with stronger and clearer, positive messages in Latino and Asian families as compared to White and African American families. Also, Asian American parents demonstrate high expectations and provide support for STEM careers as they see these as tools to gain access to status, income, stability, and success (Aschbacher, Li & Roth, 2010). Even within science, there may be significant patterns and variations with regards to students' career aspirations. Gilmartin et al. (2006), for example, found that Indian and Pakistani students in the UK choose more applied professions and careers in science (e.g., medicine, pharmacy) rather than pure science (e.g., physics, chemistry) because their family members value these applied professions. Similarly, Wong (2015) observed that careers 'in' science, such as those taken by biological and physical scientists, are not popular among most minority ethnic groups presumably because they associate such careers with 'white men'. However, careers 'from' science, such as medicine, are highly sought after by British Indian, Bangladeshi, and Pakistani students, although Chinese and Black Caribbean students preferred non-science-related careers. Finally, in the UK's scientific workforce black and minority ethnic workers are relatively concentrated in the most senior and most junior jobs, with Chinese overrepresented and black workers underrepresented in the most senior roles. Also, compared to white students, black and minority ethnic students are less likely to progress to scientific jobs after graduating (Royal Society, 2014).

In addition, the interplay between class and ethnicity could play a subtle role in influencing students' science participation. While families with White middle-class backgrounds have been suggested to more successfully deploy their resources (e.g., economic, social or cultural capital) to promote educational achievement (Ball, Maguire, & Macrae, 2000; Martin, 2009), such a process is not confined to this particular privileged group. Previous research has found that certain middle-class ethnic minority families or even some working-class ethnic minority families are able to utilise their various forms of capital in a strategic and effective way which in turn leads to greater educational outcomes for their children (Lareau, 2003; Zhou & Lin, 2005). In fact, in a recent study, Archer, DeWitt & Osborne (2015) illustrate the case of two young Black women who aspire to be scientists, and suggest that science capital could be a key enabler for science aspirations of ethnic minority children. Contributing to this stream of research, similar to Archer, DeWitt & Osborne (2015), by focusing on one particular ethnic minority group, Turkish students in London, my study aims to understand patterns of science participation within this less studied group. Although the literature reviewed in this section points to differential science participation dynamics and outcomes associated with some ethnic minority groups, there is little work on other ethnic minority groups' science participation in the UK, such as the Turkish community. To what extent is Turkish students' science participation similar or different to other well-studied groups such as Indian or Pakistani students? As the UK's immigrant and ethnic minority groups become more heterogeneous, diverse and dynamic, it is worth exploring and understanding science participation in less-studied groups.

2.4 The Turkish community in the UK

2.4.1 Population overview

The Turkish-speaking community[1] in the UK consists of mainland Turks, Kurdish Turks and Cypriot Turks. Despite having slight differences, these three groups share many common social and cultural practices. It is one of the largest minority groups in the UK with an estimated population of between 250,000 (Düvell, 2010; Thomson, 2006) and half a million (Travis, 2011). According to the 2010 census in the UK (Census, 2011), there were 120,690 people in England and Wales who identify themselves as having Turkish or Turkish Cypriot ethnicity and 48,935 people with Kurdish ethnicity. In addition, 18,755 people identify themselves as having Cypriot ethnicity without indicating whether this is Greek or Turkish. However, it is reasonable to assume that the census numbers significantly underestimate the real size of the population. This is for several reasons. First, the way the census collects ethnicity data means that unless individuals put the effort into writing their specific ethnicity, they cannot easily report that they have Turkish, Kurdish or Cypriot ethnicity (i.e., there is no direct question that indicates Turkish or Kurdish ethnicity; individuals need first to choose "White Other", "Mixed/multiple other" or "Other Ethnicity", and then specifically write Turkish, Kurdish etc. in the

[1] I use Turkish community instead of Turkish-speaking community throughout the thesis for ease of reference.

questionnaire). Secondly, they may not be willing to disclose their Turkish ethnicity due to potential immigration issues they might be concerned about. In addition, second or later generation Turks, or those with mixed backgrounds may not primarily associate themselves with the Turkish community. An important observation is that the Turkish community does not occupy a clear position in the white/non-white divide upon which current understanding of 'ethnic minorities' is based. This is evident from the census responses, as Turkish community members do select any one of the "White Other", "Mixed/multiple other", or "Other Ethnicity" categories before writing Turkish, Kurdish or Cypriot in the space provided in the questionnaire.

According to the 2010 census, a large portion of the Turkish community (72% of Turks and Cypriot Turks and 43% of Kurds) live in London. In fact, a report by the Borough of Hackney (2004) suggests that the size of the Turkish population (including those of Kurdish ethnicity) in London is around 200,000. In addition, Turkish is the 7th most spoken language other than English in London schools (von Ahn et al., 2010). Several boroughs in London have significant populations from the Turkish community. These include Hackney, Haringey, Enfield, Islington, Lewisham, Southwark, Croydon, among others (Greater London Authority, 2009).

In terms of gender, the Turkish community has quite a balanced population with about 50% male and 50% female. In terms of age structure, the Turkish community is quite young. Also, according to the 2001 census, the oldest Turkish community – Turkish Cypriots – has a very similar age structure to the London average, while the Kurdish population is significantly younger (Table 2.1). This reflects the patterns and history of immigration to the UK; the younger group (Kurdish) is the more recently migrated, and the older group (Turkish Cypriots) has the longer history in the UK.

Table 2.1 Age distribution of Turkish community (Greater London Authority, 2009)

	Mainland	Kurdish	Turkish	All

	Turkish		Cypriot	London residents
Age group	**%**	**%**	**%**	**%**
0-15	24.7	31.3	19.9	20.2
16-39	49.8	50.9	37.8	40.3
40-59/64	21.8	15.6	30.7	25.1
60/65-74	2.9	1.7	9.3	8.6
75 and over	0.8	0.5	2.4	5.9

2.4.2 A brief history

Different Turkish communities in the UK, namely mainland Turks, Kurdish Turks and Cypriot Turks, have quite distinct patterns of migration and history in the UK.

It was Cypriot Turks who first migrated to the UK in large numbers during the 1950s and 1960s. This is basically due to the island of Cyprus gaining independence from Britain in 1960. This led to the withdrawal of British military presence and the disappearance of well-paid employment opportunities that were linked to the British presence (King et al., 2008). The UK provided lots of opportunities at the time for migrants, including a welcoming immigration policy and many job prospects in the industrial and service sectors (Ladbury, 1977). The tensions between Turkish and Greek Cypriots in the new independent island speeded up the process of migration to the UK in large numbers. The eventual partitioning of Cyprus in 1974, and people's fondness with Britain as former subjects, also led to more migration in the 1970s and 1980s.

Mainland Turks were the second group to migrate to the UK in large numbers. Migration of this group started on a smaller scale in the late 1960s and 1970s as workers (and later their families) moved to the UK, mostly to work in the UK's large textile industry. This was followed by larger scale migration to the UK as workers in a range of industries. After 1980, when there was a military coup in Turkey, there were significant numbers of asylum seekers from Turkey, consisting often of professionals and other educated individuals (Erdemir & Vasta, 2007).

Finally, while Kurds from countries such as Iraq, Iran, Syria and Turkey have been migrating to the UK since the 1970s, a larger scale migration of Turkish Kurds took place during the 1980s and 1990s partly as a result of conflicts and tensions in South East Turkey. Because Kurds who migrated from Turkey to the UK were Turkish citizens, and hence recorded as Turkish, it is hard to get actual migration numbers.

Among the three groups, Cypriot Turks were the first to move to the UK, starting small businesses or being employed as skilled or professional workers. As a result, one would expect higher economic status in this group on average compared to the other two. I next discuss the socio-economic situation of the Turkish community in the UK.

2.4.3 Socio-economic status

A report prepared by the Greater London Authority (2009) provides a highly informative picture on the economic activity of the three Turkish groups (Table 2.2).

Table 2.2 Economic activity, by ethnic group, population aged 16 to 64

	Turkish	**Kurdish**	**Turkish Cypriot**	**London Average**
	%	**%**	**%**	**%**
Part-time	8.8	7.3	9.7	9.1

Full-time	17.1	8	28	46.5
Self-employed	9.2	5.2	13	9.4
Unemployed	9.9	12.8	7.7	4.7
Economically active full-time student	3.9	3	2.9	3.2
Retired	0.6	0.6	1	3.1
Economically inactive student	12.2	15	7.6	7.2
Looking after home/family	15.9	17.8	13.3	7.7
Permanently sick/disabled	6.1	7.9	8.4	4.5
Other	16.4	22.5	8.4	4.4

As expected, Cypriot Turks have the highest ratio of full-time and self-employed individuals among the three groups. However, overall, employment figures are quite low compared to the average UK population. In addition, there is a significant difference between the employment rates of the members of the Turkish community living in London vs outside London. Those living in London have much lower employment rates compared to others, and the report by the Greater London Authority (2009, p.32) suggests that this may be due to gender differences. Although in London around half the Turkish population are women, outside London only around one-third are women, and Turkish women are much less likely than men to work in paid employment.

It is estimated that there are more than 10,000 Turkish enterprises in the UK (London Development Agency, 2006). As noted previously, those within the Turkish community who came to the UK in the 1970s and 1980s mostly worked in the textile industry as tailors, trimmers, etc. At that time, it is estimated that the textile industry employed more than 90% of Turkish people living in the UK. After the end of the success of the textile trade in the UK, other trades such as those involving restaurants, fish and chip and kebab shops, cafés, supermarkets, minicabs and the import-export business have become popular among the Turkish community (London Medya Guide, 2003). Catering, retail and textiles are the three biggest sectors where the Turkish community in the UK has significant presence in the form of small shops and local businesses.

In addition, with regards to housing, while Cypriot Turks tend (58% to be owner-occupiers, a significant portion of Kurdish Turks and Mainland Turks live in rented and council accommodation. According to the 2001 Census, 40.6% of the Kurdish and 34.5% of the mainland Turkish population rents from the Council, a much higher figure than general London population average which is 26%.

Table 2.3 Turkish community housing statistics (Greater London Authority, 2009)

	Mainland Turkish	Kurdish	Turkish Cypriot	All London residents
	%	%	%	%
Owns outright	8.5	3.8	19.1	22.1
Owns with a mortgage or loan	22	9.2	38.9	33.5
Shared ownership	1	1.3	0.4	1
Rented from Council	34.5	40.6	23.4	17.1

Other social rented	12.1	18.1	7.7	9.1
Private rented	15	15.4	7.7	14.3
Other	6.8	11.7	2.8	2.9

2.4.4 Community, culture, social life

While Turkish is the main language of the community, a notable number of Kurdish Turks speak various dialects of Kurdish which primarily consists of Kurmanji, Sorani and Zaza. Although most Kurdish men can speak Turkish, if they did not attend school, Kurdish women may not be able to. According to surveys of London schools conducted in the education authorities, Turkish is the second most spoken language in schools in Haringey, Enfield and Islington after English with percentages ranging from 8.8% to 17% of pupils (Baker & Eversley, 2000).

An important problem in the Turkish community regarding language is the lack of good English skills, particularly for Turkish women (Önal, 2003). This is thought to have far reaching consequences in terms of employment prospects, integration, etc. (Turkish Speaking Community Engagement Project, 2005). Having the command of one's host country's language is an important dimension in migrants' general adaptation and functioning, and their interactions with schools (Yeh et al., 2008).

In terms of integration within the UK, Turkish Cypriots along with second generation Turkish and Kurdish immigrants are suggested to be better integrated than first generation people of mainland Turkish and Kurdish-Turkish origins (Robins & Aksoy, 2001). This is likely to be related to overall higher socio-economic status of immigrant Turkish Cypriots in comparison to people of mainland Turkish and Kurdish-Turkish origins (Robins & Aksoy, 2001). With regards to religion, a large majority of the Turkish community are Muslims, with some of Kurdish-Turkish people coming from an Alevi Muslim background which has notable differences in terms of religious practices compared to the larger Sunni Muslim community.

The Turkish speaking community in the UK has a large number of community organisations, associations and social centres; there are weekend schools that teach Turkish and Kurdish, and cultural (art, music etc.) and religious classes are quite popular within the community. As a result of satellite TV, many Turkish immigrant families in the UK can readily watch TV channels from Turkey, and some Turkey-based TV shows are highly popular among the community. There are six London-based Turkish newspapers, and there is one Turkish radio station broadcasting from London. Each year there are around five to ten large festivals organised in London by various organisations in the Turkish community.

2.5 Turkish children and education

Low levels of educational attainment by young people are seen by community leaders as the most pressing issue for the Turkish community in the UK (see, for example, Sonmez (2011) for an interview with the Turkish Consulate General in London). Similarly, a report by Greater London Authority (2009) emphasises this problem stating: "Where information is available on detailed ethnic groups, the achievement levels of Turkish, Kurdish and Turkish Cypriot pupils has been a cause for concern" (p.19). In fact, Turkish students, both boys and girls, have been among the lowest achieving minority groups in the UK (Moodood et al., 1997), and OFSTED reports that for test scores, among those students who spoke English as a second language, "Somali, Kurdish, and Turkish speakers performed considerably worse than others" (TES, 2003). In 2008, the Department for Children, Schools and Families prepared a National Strategies report for secondary school education with the title 'Raising the attainment of Pakistani, Bangladeshi, Somali and Turkish heritage pupils' which indicates that Turkish pupils low achievement is a cause for concern. In this report (Department for Children, Schools and Families, 2008, p.8) the following aims are described:

- To ensure that the educational aspirations of Pakistani, Bangladeshi, Somali and Turkish communities and their children are realised.

- To raise the attainment of pupils of Pakistani, Bangladeshi, Somali and Turkish heritage and narrow the achievement gap.

- To support the development of inclusive approaches to learning and teaching.

- To strengthen school partnerships with parents and the community to improve the learning of pupils.

In a study examining the educational attainment of young Turkish people in the UK, Issa, Allen and Ross (2008) demonstrated the underachievement problem for Turkish children. In Figure 2.1 below, when Turkish or Kurdish students are compared with the local educational authority average (in the London Borough of Haringey), there is a clear achievement gap in all three subjects at KS2: English, Mathematics, and Science.

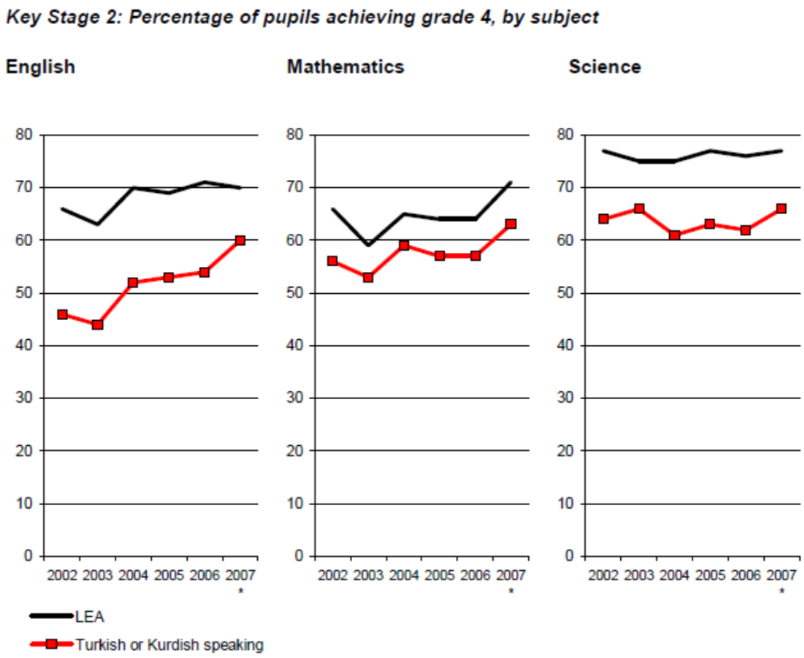


Figure 2.1 London Borough of Haringey Key Stage 2 Results (Issa, Allen & Ross, 2008)

Similarly, according to a report by the Department for Education and Skills (2005), nationally in 2003, only 30 per cent of Turkish/Turkish Cypriot pupils attained five or more GCSEs at grades A* to C, compared with an average of 51 per cent of all pupils. This improved slightly by 2005, with 40 per cent of Turkish and Kurdish pupils attaining five or more A* to C graded GCSEs, compared with a national average of 55 per cent for all pupils in maintained schools. Clearly, Turkish minority students typically under-attain both at KS2 and at GCSE.

Although later reports suggest that the attainment gap between Turkish students and others are decreasing, there are still significant differences. For example, according to a report by London Borough of Enfield (2012), Turkish pupils perform around 10% lower than the average at both Key Stage 2 and Key Stage 4 English and Maths (see Figures 2.2 and 2.3 below).

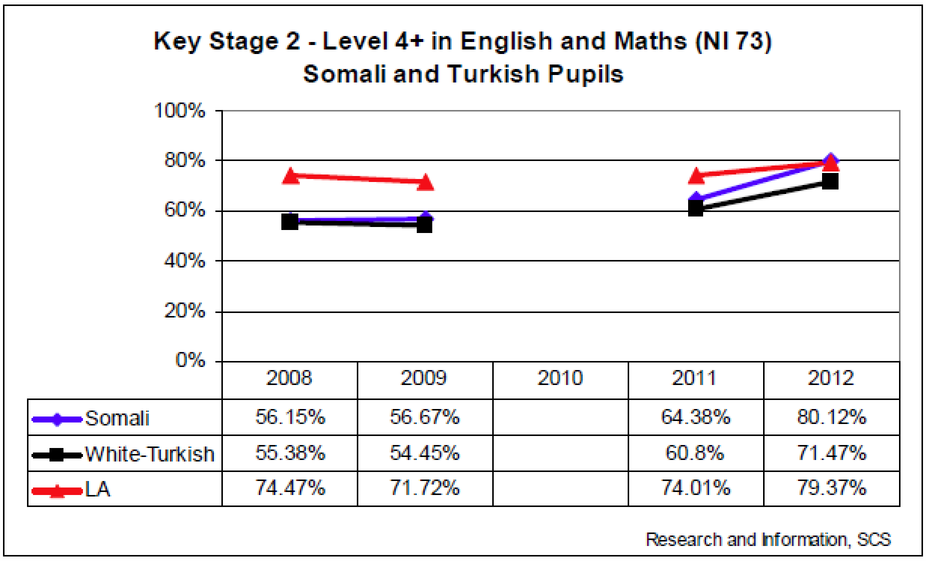
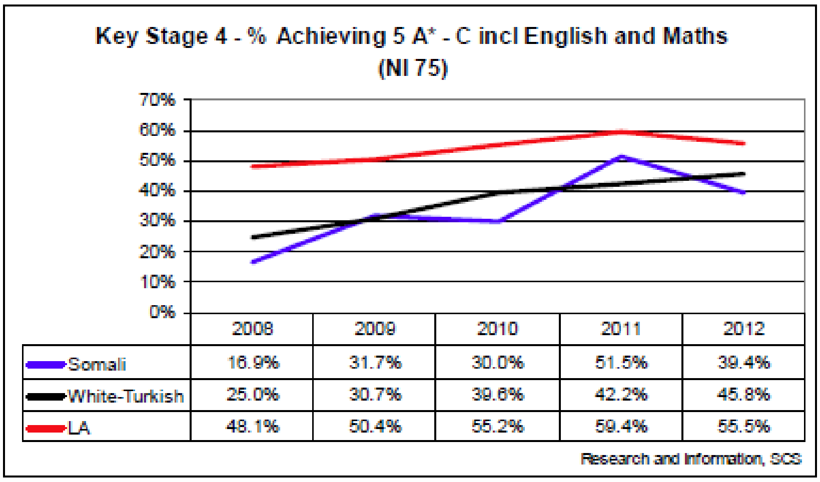


Figure 2.2 London Borough of Enfield Key Stage 2 Results



	2008	2009	2010	2011	2012
Somali	16.9%	31.7%	30.0%	51.5%	39.4%
White-Turkish	25.0%	30.7%	39.6%	42.2%	45.8%
LA	48.1%	50.4%	55.2%	59.4%	55.5%

Figure 2.3 London Borough of Enfield Key Stage 4 Results

These observations which clearly suggest some improvement, but still significant underachievement of Turkish pupils are not unique to one or two boroughs, but a common finding across a variety of localities. For instance, in addition to above examples from Enfield and Haringey, Hackney demonstrates a very similar pattern where there is a significant gap between local authority average and Turkish pupils' average in key stage 1 and 2 results.

Educational under-achievement among children in Turkish, Turkish Kurdish and Turkish Cypriot communities in the UK has been documented and examined by several researchers (Dedezade, 1994; Enneli, Modood & Bradly, 2005; Issa, Allen & Ross, 2008; Mehmet Ali, 2001; Swann Report, 1985). A significant number of members of the Turkish community rely on family establishments (restaurants and supermarkets) and most of them expect their children to take over the business. There is also the additional incentive of earning more in the family business than they normally would in another profession. Some young Turkish people believe they suffer discrimination and harassment from white people, from some minority groups and even from some other Turkish groups (Enneli, Modood & Bradly, 2005). Also, in the UK, very few Turks occupy visible or high profile positions within academia, local authorities, business or in parliament.

2.6 Summary and research questions

The literature review discussed in this chapter and the overview of the research context – Turkish immigrant students in London – has revealed several under-explored issues and gaps which then form the research questions studied in this thesis. First, there appears to be a notable science attainment and aspiration gap in Turkish children in London. Indeed, several boroughs in London which have significant Turkish population, such as Haringey and Enfield, documented this problem over multiple years. Similarly, multiple reports such as the one for the Greater London Authority highlighted this issue stating: "The achievement levels of Turkish, Kurdish and Turkish Cypriot pupils has been a cause for concern" (Issa, Allen & Ross, 2008 p.19). In addition, among those students who spoke English as a second language, Turkish speaking students were found to perform worse than others (TES, 2003). While previous research has documented science interest and achievement differences between different ethnic minority students, with, for example, Asian and Chinese students performing better than others (Abbas, 2004; Elias et al., 2006), Turkish students have received very limited research attention. A limited number of studies and reports that examined Turkish students have not focused on science specifically, but considered educational achievement in a broad, general way, and suggested factors like a focus on small family businesses, lack of role models, and possible discrimination as possible reasons for the observed gap in attainment and aspirations. Considering limited existing work on Turkish minority students' science participation and further complexities added by the family, cultural contexts and ethnicity in students' development of science attitudes and aspirations as highlighted in the literature review in this chapter, the first aim of this study is to address this gap and provide an understanding of the patterns of science participation of Turkish minority students.

Secondly, as the research reviewed in this chapter demonstrates, children's science outcomes are patterned by social structures such as socio-economic background (Hampden-Thompson & Bennett, 2011) and ethnicity (Elias, Jones, & McWhinne, 2006; DeWitt et al., 2010). Their engagement with science is also shaped by parents' science-related attitudes, dispositions, behaviours and practices (Archer et al., 2014; Archer & DeWitt, 2017). While such social structures clearly matter, previous research has also cautioned against overstressing the role of demographics, ethnicity and socio-economic position in children's science participation (Falk, 2009; Carter & Fenton, 2010; Ulriksen, Madsen, & Holmegaard, 2010). Indeed, developing science capabilities is a multifaceted phenomenon and like any capability it depends on a variety of factors, including personal characteristics, agency and social arrangements (Sen, 1999). That is, even within the same social structures and social groups, patterns of science capabilities may vary based on agency dynamics. The literature review presented in this chapter raises questions on science-related capability formation in Turkish children which may be actively constructed by agency and choices made by parents but at the same time constrained and shaped by structures. Therefore, an important goal of this study is to explore factors not only related to cultural and social contexts but also parental involvement and practices for their influence on the development of science capabilities for Turkish children.

Thirdly, while previous research has identified several outside-school factors that promote or inhibit children's science attitudes and aspirations, the relationship between these factors and children's science engagement has been suggested to be subtle and complex (Atherton et al., 2009). In the case of Turkish immigrant children who occupy several simultaneous identities and social positions (e.g., belonging to an ethnic minority group, having working-class parents, coming from a low socio-economic background), as a result of this multifaceted identity combined with personal and familial characteristics, and practices of Turkish community in London as outlined in the literature, there may be emerge additional factors that can affect the formation of Turkish children's science-related attitudes and aspirations.

Fourthly and finally, despite possibly sharing similar family 'habitus', that is similar familial values, dispositions, cultural discourses and identifications, Turkish children's science-related capability development could be different in Turkey as compared with London, which could be at least partly explained by the immigrant identity and experience of the Turkish community in the UK as outlined in this chapter. In fact, comparing migrants who have moved to a new country with those who stayed in the place of origin has been suggested to provide critical insights in understanding factors associated with migration (Fitzgerald, 2006; 2012).

The literature review presented in this chapter and summarized in this section raises four research questions that will be investigated in this thesis:

1. How can we explain patterns of science participation of Turkish minority students?
2. How do cultural contexts and parental attitudes, involvement and practices influence immigrant Turkish students' formation and expansion of science capabilities?
3. What other outside-school factors promote or inhibit immigrant Turkish students' attitudes and aspiration in science and how?
4. How are immigrant Turkish students similar or different in their science capability and functioning development compared to their counterparts in Turkey?

3 Chapter Three: Theoretical approach

3.1 Introduction

Because my study focuses on outside-school factors and examines complex relationships, such as those between the student, his/her parents, and cultural contexts, I base my work on two sociologically-informed theoretical foundations; the first one is Pierre Bourdieu’s work on *habitus, cultural and social capital*, and *field* and the second one is Amartya Sen’s *capability approach*. Although these frameworks have been used extensively by education researchers, their use has been somewhat limited in the context of science education. There are several papers that employ Pierre Bourdieu’s work in science education (notably Adamuti-Trache & Andres, 2008; Archer et al., 2012; Brandt et al., 2010; Elmesky & Tobin, 2005; Wong, 2012), and I believe this work is the first one that uses Amartya Sen’s *capability approach* in the context of science education. A novel contribution of this study is to combine and reconcile these two major frameworks in explaining the role of outside-school factors in science education (Gokpinar & Reiss, 2016).

3.2 Bourdieu’s habitus, cultural capital and social capital, and field

Habitus is a critical and complex concept in Bourdieu’s work which explains how individuals’ social actions, practices and dispositions are formed and affected by their social world and specific experiences. Bourdieu (1977, pp.171-172) defines *habitus* as:

> both the generative principle of objectively classifiable judgments and the system of classification of these practices. It is in the relationship between the two capacities which define the habitus, the capacity to produce classifiable practices and works, and the capacity to differentiate and appreciate these practices and products (taste), that the represented social world is constituted.

Maton (2012) summarizes the key characteristics of *habitus* as follows: (i) it is 'structured' by individuals' past and present circumstances, such as educational and family experience; (ii) it is 'structuring' in the sense that it helps individuals form certain set of practices; and, finally, (iii) it is a 'structure' that is comprised of systematic dispositions that generate perceptions, appreciations and practices. *Habitus* is a powerful tool that links individuals' past, present, and future. It captures how my current dispositions and tendencies are formed by my history, experiences, and upbringing, and how my current dispositions and tendencies in turn lead to certain dispositions and actions in the future.

Although some critics have argued that there is inherent determinism in *habitus* and its use in education research should be very limited (Alexander, 1995; Jenkins, 1992; Tooley & Darby, 1998), others have pointed out its useful function in mediating between various dichotomies such as structure and agency, and the social and the individual (Maton, 2012; Nash, 1999). *Habitus* generates a scheme that is embodied in individuals through their socialization and social interactions. This scheme consists of beliefs and dispositions that are the results of childhood experiences, and individual and family history as well as cultural codes. That is, "the structural code of the culture is inscribed as the habitus and generates the production of social practice" (Nash, 1999, p.177). *Habitus* can play both a transformative and a constraining role in producing a wide set of actions, so although it allows for individual agency, it may also bias individuals to act in certain ways (Reay, 2004).

Although *habitus* in itself is critical in Bourdieu's work in determining and explaining individuals' dispositions, I am interested in its interaction with *cultural capital* in social reproduction and agency formation in the context of students' attitudes towards science and science-based careers.

Bourdieu (2008) argued that there is a strong connection between owning different kinds of capital, a class-specific habitus and the choices individuals have. The formation of *habitus* depends on the availability of different kinds of capital and these capitals are characterized by Bourdieu (1986) as being of three major forms: *economic capital, social capital*, and *cultural capital*. *Economic capital* is in monetary or material form, representing financial resources, and is critical in reproducing social advantage and disadvantage. *Social capital* includes both material and non-material resources that one possesses through a network of connections one can effectively mobilize. Finally, *cultural capital* is gained mostly through social learning and constitutes people's symbolic and informational resources for action.

Cultural capital is the valued knowledge that exists in three forms: (i) it can be *objectified*, that is materially represented in things such as books, museums, art works, etc.; (ii) it can be *embodied*, that is in predispositions such as skills, body language, etc.; and, finally, (iii) it can be *institutionalized* such as in educational degrees and certificates (Bourdieu, 1986). *Cultural capital* is partially formed by formal education, but it captures more than that. It includes different cultural skills – most individual action is determined by cultural capital – and it depends heavily on "total, early, imperceptible learning, performed within the family from the earliest days of life" (Bourdieu, 1984, p.66). Social capital, on the other hand, is at the inter-individual level, which involves social relationships that are directly usable in the short or long term. A key feature of social capital is that it transforms contingent relationships (e.g., those at the neighbourhood, the workplace, kinship) into durable relationships that are both necessary and elective at the same time (Bourdieu, 2002). Bourdieu (1986, p.51) characterises it as follows:

> Social capital is the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition – or in other words, to membership in a group – which provides each of its members with the backing of the collectivity-owned capital, a 'credential' which entitles them to credit, in the various senses of the word.

The third concept that I focus on, which is also highly related to habitus and cultural and social capital, is *field*. Field provides the context in which the potentialities of the habitus are activated (Bourdieu & Waquant, 1992). In addition, various capitals are invested and their values are realised in a field whose structure is the source of the specific effects of capital (Bourdieu, 2002). Consequently, individuals with similar habitus or cultural and social capital can demonstrate very different practices or positions if there is variation in their fields (Bourdieu, 1990). A field can be, for example, a higher education institution, a family, a town, a profession, and each field develops a distinct logic of its own, a natural understanding of the world and implicit and explicit rules of behaviour.

Field is like a game with rules. Individuals may have different capitals with which to play; they may vary in their understanding of the rules of the game and in their dispositions (Bourdieu & Wacquant, 1992; Reay et al., 2008). Field's effect on habitus is twofold. First, the effect can be characterised as conditioning, that is, the field structures the habitus which "is the product of the embodiment of the immanent necessity of the field" (Bourdieu & Wacquant, 1989. p.44). Secondly, the relationship can be viewed as one of knowledge and cognitive construction, that is "habitus contributes to constituting the field as a meaningful world, a world endowed with sense or with value, in which it is worth investing one's energy" (Bourdieu, in Wacquant, 1989, p.44).

Bourdieu (1986, p.48) highlights the role of education in social reproduction by pointing its interaction with cultural capital:

> the contribution which the educational system makes to the reproduction of the social structure by sanctioning the hereditary transmission of cultural capital. From the very beginning, a definition of human capital, despite its humanistic connotations, does not move beyond economism and ignores, *inter alia*, the fact that the scholastic yield from educational action depends on the cultural capital previously invested by the family. Moreover, the economic and social yield of the educational qualification depends on the social capital, again inherited, which can be used to back it up.

Bourdieu's concepts and social reproduction theory has been extensively used and discussed in education research. His key concepts of habitus, field, and capitals can be instrumental in understanding and conceptualizing structured limitations faced by some (e.g., working class, ethnic minority, etc.) students. Crozier et al. (2008, p.168) nicely illustrate this:

> Bourdieu likens the field to a game with rules and competition. Not everyone has equal knowledge of the rules. Some have ‘trump cards’ (Bourdieu and Waquant 1992, 98) and different amounts and quality of ‘capital’ with which to play. They also have differing dispositions – habitus – to operationalise these. Hence, there are power dynamics and contestation within all fields. The fields are the context of scarce resources: in our study, ultimately high level qualifications but also access to tutor time, materials, knowledge sources, etc – conducive to studying, and a source of accruing further capital. The ‘players’ or students in our study thus need strategies and resources and dispositions to ‘play’. They also need commitment and acceptance that the game is worth ‘playing’ or as Bourdieu terms it, ‘illusio’ (ibid. 98). The engagement with the game is different depending on the resources students bring to it or subsequently accrue. Arguably some are more aware of the game than others.

When I develop and discuss my theoretical model in Sections 3.4 and 3.5, I will pay close attention to structured limitations as illustrated by Crozier et al. (2008) and their potential role in a capability-based perspective in science education.

3.3 Sen’s capability approach

Amartya Sen (1997, 1999) defines capabilities in simple terms as what people are actually able to do and to be. The basic reasoning behind this approach is that it is not sufficient for individuals to have resources or the end product of these resources (e.g., income, status, money, etc.), but they should be able to develop their capabilities, and this ability and freedom is the key to wellbeing (Nussbaum, 2003; Sen, 1999). The capability approach is an interdisciplinary framework to study and evaluate human wellbeing. The appealing characteristic of the capability approach is that it takes a multidimensional view of human wellbeing, and primarily focuses on human capabilities, which are defined as “a person’s ability to do valuable acts or reach valuable states of being; [it] represents the alternative combinations of things a person is able to do or be” (Sen, 1993, p.30). This approach is very different from the earlier outcome- or utility-oriented view of human wellbeing which looks at people’s happiness, standard of livings, income or consumption. The capability approach makes a clear distinction between outcomes (achievements) and freedoms to choose. It is the freedom to choose, and the potential and opportunity to achieve a desired outcome that matters in the capability approach.

Considering the education context, in the capability approach, what matters is opportunities given to people (regardless of their gender, ethnicity, social class, etc) so that they learn how to read and write, providing them with books, teachers, good teaching and learning settings, supportive environments, etc. These opportunities provide people with the freedom to choose, and with this freedom they will become or achieve things that they find meaningful and valuable through their own reflection. The goals that they achieve (i.e., outcomes) may not make their lives more comfortable, may not raise their standard of living or their happiness but, again, in the capability approach the core focus is on the freedom to shape one’s own life and the ability to achieve goals that matter to oneself.

The capability approach was defined and introduced by the economist and philosopher Amartya Sen, who was later awarded a Nobel Prize in Economics for his contributions to welfare economics. The capability approach in itself is not a theory to explain wellbeing, social justice, poverty, or development; rather, it is a framework that offers tools and a rich set of ideas to conceptualize and evaluate these phenomena (Robeyns, 2005). Sen’s capability approach has its roots in early political economy, welfare economics and political philosophy. For example, in his various writings and reflections, Sen (1980, 1984, 1992, 1993, 1999) suggested that his work is conceptually linked to Aristotle’s central concept of *eudaimonia* (human flourishing), Adam Smith’s (1776) views on necessities and Karl Marx’s (1844) thoughts on human emancipation.

The key distinction of the capability approach is the move from the utilitarian perspective to a freedoms perspective when evaluating wellbeing. Sen (1999) suggests that the actual diversity of human beings challenges the utilitarian perspective, and at the practical level “differences in age, gender, special talents, disability, proneness to illness, and so on can make two different persons have quite divergent opportunities of quality of life even when they share exactly the same commodity bundle" (Sen, 1999, p.69). Therefore, he proposes that "for many evaluative purposes, the appropriate 'space' is neither that of utilities (as claimed by welfarists), nor that of primary goods (as demanded by Rawls), but that of the substantive freedoms – the capabilities – to choose a life one has reason to value" (Sen, 1999, p.74).

Sen's capability approach has been popular in the social sciences for several reasons. This approach not only specifically focuses on people as ends in themselves (not as passive agents in economic activity or for what they achieve, but rather what they are capable of achieving), but it also recognises human diversity and heterogeneity. That is, people are diverse and heterogeneous with different personal conversion functions that they carry, and this difference leads to different outcomes. In addition, Sen emphasizes different group dynamics (e.g., gender, race, class, caste or age), considers agency and freedom as key concepts, and also acknowledges the role of cultures and societies on people's values and aspirations (Clark, 2005). In short, Sen's capability approach is a rigorous yet flexible and pragmatic approach for studying human wellbeing and many related concepts. I next discuss the central concepts in the capability approach.

Functionings. Functionings are valued outcomes that are achieved by individuals. A functioning is "an achievement of a person, what she or he manages to do or to be" (Sen, 1985, p.10). The concept of functionings has roots in Aristotelian views, and it "reflects the various things a person may value doing or being" (Sen, 1999, p.75). The valued functionings could involve a diverse set of activities or personal sets. This may range from basic ones, such as being adequately nourished, healthy and literate, through common ones such as working or resting, to more complex ones such as being able to take part in the life of the community and having self-respect (Sen, 1999).

Capabilities. Capability is the ability to achieve (i.e., doing or being) desired functionings. A person's 'capability' refers to the alternative combinations of functionings that are feasible for her[2] to achieve. Capabilities are “a kind of freedom: the substantive freedom to achieve alternative functioning combinations” (Sen, 1999, p.75). Sen gives the example of fasting in this context. A wealthy person who is fasting and a poor person who does not have food to eat and starves may have the same functioning achievement, but their capability sets differ substantially. While the first one can choose to eat well and be well nourished, the second one cannot (Sen, 1999, p.75). The capability approach suggests that I should not simply look at the functionings of individuals; rather, I should focus on the freedom and opportunities available to each individual so that they achieve what they value.

Agency and freedom. ‘Agency’ is an important element in Sen’s capability approach. Agency in his view acts and brings about change, and it means that an individual’s achievements can be judged in terms of her own values and objectives. Sen emphasizes the agency role of the individual as a member of the public and as an active participant in economic, social and political actions. This means being directly or indirectly involved in individual or joint activities for positive social change (Sen, 1999, p.75).

Agency and freedom are two connected concepts, as humans cannot exercise their reasoned agency without individual freedoms. Sen argues that people should be in charge of their own wellbeing and they should themselves decide on how to use their capabilities (Sen 1999). In order to achieve this, they need both individual freedoms and related suitable social arrangements. Because the actual capabilities a person has critically depend on the nature of social arrangements, when I consider the capability approach, I should take note of both an individual’s agency and her freedom in exercising this agency.

Conversion factors. An important element in Sen’s capability approach are conversion factors. These basically are factors that convert an individual’s resources into valued functionings (Sen, 1992). The importance of the conversion factors is that they take into account diversity and individual circumstances. Sen argues that: “If the object is to concentrate on the individual’s real opportunity to pursue her

[2] In places, to avoid circumlocutions, ‘she’ and ‘her’ are used whether an individual is male or female.

objectives, then account would have to be taken not only of the primary goods the persons respectively hold, but also of the relevant personal characteristics that govern the conversion of primary goods into the person's ability to promote her ends" (Sen 1999, p.74). Sen (1999) also suggests that there may be systematic variation in conversion of incomes into distinct functionings because of different types of contingencies. In his review essay on the capability approach, Robeyns (2005) summarizes three groups of conversion factors which are (i) personal, (ii) social and (iii) environmental. Personal conversion factors include physical condition, gender, reading skills, intelligence, etc.; social conversion factors include social norms, gender roles, societal hierarchies, etc.; and environmental conversion factors include geographical location, etc.

Capability approach in education. In his work, Sen does not specify a list of specific capabilities or important functionings, nor does he provide an outline of how to weigh the importance of various capabilities or functionings. Some researchers argue that this makes the capability approach harder to operationalize and limits its potential use (Nussbaum, 1988; Sugden, 1993; Williams, 1987). However, in his later writings, Sen addresses these criticisms and argues quite convincingly that it is this general and flexible nature that provides the distinctive strength of his approach. For example, in Sen (1999, p.86) he says: "A general approach can be used in many different ways, depending on the context and on the information that is available. It is this combination of foundational analysis and pragmatic use that gives the capability approach its extensive reach".

The capability approach offers a rich framework to conceptualise and study several questions related to the field of education with regards to policy, practice and social issues. For example, in their book *Amartya Sen's Capability Approach and Social Justice in Education*, Walker and Unterhalter (2007) bring together articles that explore a diverse range of issues in education. Research that incorporates the capability approach in educational contexts and addresses education-related questions has examined a wide range of topics including gender and equality (Unterhalter, 2007), higher education pedagogies (Walker, 2006), disability and special needs education (Terzi, 2005), higher education and participation (Watts & Bridges, 2006), education management and leadership (Bates, 2007), and international education (Biggeri, 2007). In education research, the capability approach has been suggested as being particularly useful in areas such as assessment and evaluation. Instead of focusing on outcomes (e.g., examination results), desire satisfaction, or resource allocation (e.g., spending per student), focusing on actual educational choices and available freedoms to pursue one's valuable and meaningful goals could be a better option (Unterhalter et al., 2003) as similar functionings may mask very different capability sets (Walker & Unterhalter, 2007).

Walker and Unterhalter (2007, pp.4-5) offer a good illustration of this:

> Two young women complete a degree in literature at the same English university. One, from a middle-class, reasonably affluent background and a good school, wished to experience university before working in her father's business as a trainee manager. An outstanding degree result was not required. Nonetheless she coped well with the academic demands of her course, having been suitably prepared by her school. She enjoyed the challenges entailed in contesting ideas in seminars. The second young woman, from a working-class background and a struggling inner city state school, despite significant academic ability, struggled to fit in and make friends among her middle-class peers. The teaching methods at her school had not prepared her well for higher education. Contestation over ideas in class undermined her confidence and made her anxious and unwilling to advance an opinion. She nonetheless worked hard, desperate to get excellent grades, but her lack of confidence meant she blamed herself for her struggles and was reluctant to approach her tutors for help with work. Both students obtained second-class passes. This shows that similar functionings mask very different capability sets.

The capability approach emphasizes human freedom at an individual level, and it strives to create an environment that is suitable for individuals to improve their daily lives and realise their full potential. Saito (2003) suggests that education can play a critical role in expanding capabilities and providing new opportunities. She analyses the relationship between education and the capability approach and identifies two key roles, namely the enhancement of capabilities and opportunities, and the development of judgement in exercising these capacities. Saito (2003) also suggests that education can play a critical role in the expansion of capabilities and provision of new opportunities. She claims that providing compulsory education is important and necessary, but it is not enough for enhancing capabilities.

The benefit of education for agency freedom has also been highlighted, for example Schuller et al. (2004, p.190) wrote:

> The important function it [education] provides is enabling people to have a sense of a future for themselves, for their families and perhaps also for their communities, which they can to some extent control or influence. Several of our respondents spoke about having a sense of agency which they did not have before. In other words, education provides a kind of choice in life. The notion of choice is present in ways which did not previously exist and horizons are extended beyond what might have been imagined.

While Sen's capability approach has not been applied directly in the science education literature, the emphasis on freedom and choice is not entirely new. For example, Falk and Dierking (2000) introduced their 'Contextual model of learning' as a theoretical construct for investigating learning within free-choice settings (e.g., in museums). Learning is conceptualised as a contextually driven effort to make meaning, which is a process/product of the interactions between an individual's personal, sociocultural and physical contexts over time. Therefore, for example, depending upon who the visitor is, what they know, why they come, and what they actually see and do, the outcomes of the museum experience could be dramatically affected (Falk & Storksdieck, 2005). My study also highlights free choice and outside-school settings, and the role of contextual factors in science education, but by incorporating Sen's capability approach, I hope to introduce a more granular view of outside-school factors that may act as conversion factors in science-related capability and functioning development.

3.4 Theoretical model: Combining Bourdieu and Sen

In this model, I use and combine the two perspectives of Pierre Bourdieu and Amartya Sen in examining the role of outside-school factors in science education. More specifically, I develop a two-stage model to characterise the mechanisms of how outside-school factors affect students' attitudes, aspirations, and capability formation in science. In the first stage of the model, I identify habitus, cultural and social capital, and field as Bourdieu's key ideas to help conceptualize how science-related resources and capitals are formed outside the school. In the second stage, these resources are turned into science-related capabilities. These science-related capabilities can then be turned into science-related functionings such as career aspirations. I outline the model in Figure 3.1.

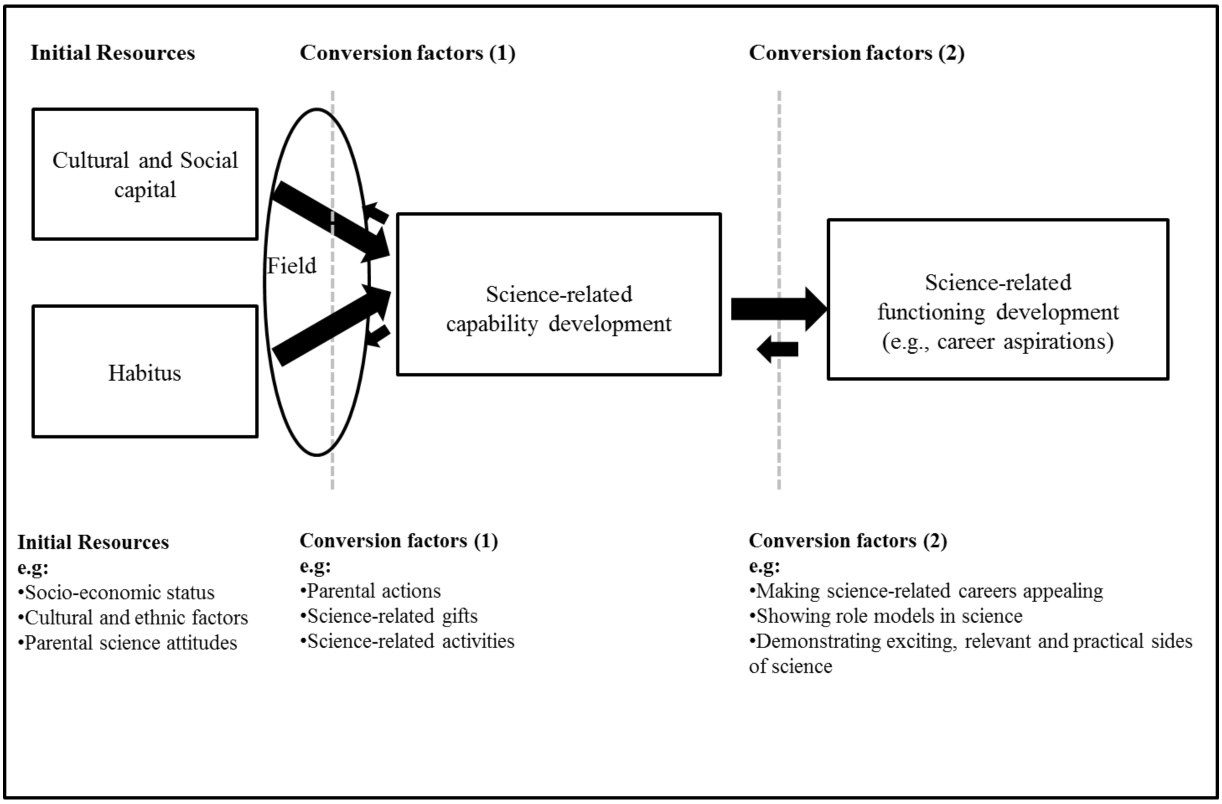


Figure 3.1 Combining Bourdieu and Sen in Science Education

There are only a small number of previous studies that make use of and combine the perspectives of Bourdieu and Sen. Schuller et al. (2004) first conceptualize individual diversities as forming a triangle with three types of capitals – human, social, and identity – and then suggest that these capitals comprise capability-based assets which exist and which can be mobilised to yield returns. Although their paper is more policy-oriented, they provide a clear discussion about the features and economic characteristics of various kinds of capitals and how they may be linked to Sen’s capability framework. In a paper that explores health inequalities, Abel and Frohlich (2012) examine how and why low socio-economic position is associated with less likelihood of being in good health. They first discuss and use Bourdieu’s different forms of capitals and habitus to explain how the unequal distribution of resources could lead to reproduction of unequal life chances and health inequalities. They also point out the limitations of the concept of habitus in explaining the role of agency for structural change, namely the linkage between sociological explanation and public health action. Consequently, they propose Amartya Sen’s capability approach as a very useful link between capital interaction theory and public health action to reduce health inequalities. Although the field of their paper is medical sociology and the main question is how to reduce health inequalities, Abel and Frohlich (2012) provide a detailed discussion as to why a capital-based explanation is limited and how Sen’s capability approach could be positioned in a structure-agency perspective to address the main principles of health promotion. Finally, in her book, Hart (2012) blends Amartya Sen’s capability approach and Bourdieu’s concepts to explore the development of aspirations and capabilities. Studying the development and nature of aspirations and then their transformation to capabilities, her research focuses on education policy and social justice issues. Hart (2012) uses three main concepts from Bourdieu – habitus, capital and field – and suggests that commodification of individual capital could lead to individual capability through conversion factors. Her work provides useful insights on the potential benefits of applying Sen and Bourdieu together in studying aspirations and social justice in education. She suggests that such a framework:

> deepens understanding of the processes involved in the development of an individual’s capabilities. My freedoms are limited in the sense that from the beginning of life I do not choose my race, birthplace,

> nationality or gender. In other words, I are not in a position to choose some of the fundamental variables upon which discrimination and inequality have been based for centuries. Individuals are born into different circumstances and the effects of this cannot be completely erased. In synthesizing the thinking of Sen and Bourdieu I may be able to develop an approach to social justice where policymakers and practitioners working with children and young people strive to ensure that as far as possible individuals are free to choose a life they value. This would need to involve acknowledging the inequalities produced by the interaction of different individuals' habitus in the broad field of education. (Hart, 2012, p.63)

Although my model has similarities to Hart (2012) in the sense that I also have capitals converted to capabilities, there are significant differences. First, instead of focusing only on aspirations, I examine the formation of two elements with regards to science: students' science attitudes/interests and their career aspirations in science. And secondly, because my main research question is about the mechanisms and factors outside the school that influence students' science attitudes, aspirations, and capabilities, my model explains how various outside-school factors (i) help form initial resources, and then (ii) help convert these capitals into to science-related capabilities and then functionings.

3.5 Discussion of the model

My model starts with Bourdieu's cultural and social capital, and habitus. Although various forms of capital exist, Bourdieu (1997) states that cultural capital is the most valuable in the educational field. Habitus, which can be defined as the internalization of the social structure, actually creates one's worldview and acts as a guide for an individual's life. Both cultural capital and habitus are formed, realised and first transmitted at home during primary socialization (Swartz, 1997). Early in childhood, with interactions within the family, an individual starts to understand her position in society and what she is expected to achieve. This understanding is based on the family into which she is born, and has a life-long effect on her attitudes, decisions and actions (Dumais, 2006).

The value of the capital is determined and habitus is recognised in a specific field. It is the interaction of habitus, forms of capital and field that produces the logic of practice (Bourdieu, 1990; Reay 2004). In fact, Bourdieu was quite specific in relating habitus, capital, field and practice, suggesting: (Habitus x Capital) + Field = Practice (Bourdieu, 1984, p.101). Translating this to my model, I argue that for children, their parents, family and socio-cultural environment provide an initial habitus and capital related to science which are formed through social relationships in less than a conscious manner (Bourdieu, 1990; Farnell, 2000).

My understanding of science–related habitus and cultural and social capital is somewhat similar to Archer et al.'s (2012) conceptualisation of family habitus in their study of students' science aspirations. That is, I also want to examine "the extent to which the everyday family 'landscape' shapes, constrains, or facilitates aspirations and engagement in science through the combination of attitudes, values, practices, and ways of being that they engage in" (Archer et al., 2012, p.886). My main departure is that, while Archer et al. (2012) consider family habitus as an all-encompassing term including family resources, practices, values, cultural discourses and identifications, I want to develop a granular view by employing Bourdieu's distinct but related terms of habitus, cultural and social capital and field and combine this with Sen's capability approach.

My conceptualisation using a Bourdieuian lens helps us better comprehend science-related capitals beyond the well-studied views of family socio-economic status, ethnicity or cultural background. First, a family's socio-economic status could be a factor affecting their children's initial science-related capital (Aschbacher et al., 2009) where a relatively wealthy or better educated family could be well-versed in science, or simply have a better network and access to people in science careers (doctors, scientists, etc.). But socio-economic status (SES) alone cannot explain the formation of this initial science-related capital. It is quite possible that a lower SES family provides a higher science-related capital to their children (perhaps because of their personal interest) than a higher SES family with very limited interest and relationship to science.

A second important factor affecting the initial science-related capital is cultural and ethnic background. For example, within certain cultural contexts, and ethnic groups, science and scientists may be regarded more highly than they are within other cultural contexts and ethnic backgrounds (Gilmartin et al., 2006; Huang et al., 2000). It may also be the case that individuals from certain religious or other cultural backgrounds may be more or less open and enthusiastic than others in talking about science-related concepts (Sjøberg & Schreiner, 2005). Finally, independent of the previous factors, some families may provide a higher science-related capital to their children just because of higher personal interest in science (Cleaves, 2005; Gilbert & Calvert, 2003), a science-related job, or a familiar role model in science.

In understanding the role of outside-school factors in science education, Bourdieu's framework is not only useful for my conceptualisation of science-related resources, but also for access, inclusion and equity issues. Bourdieu's (1986) discussion of transmission, accumulation and conversion of various forms of capital helps us understand reproduction of inequalities in science education. First, different forms of capital are transmitted to children from their parents. These can include simple inheritance of economic capital to more nuanced inheritance of cultural capital, practices and dispositions such as enjoyment of museum visits or science reading that can provide an advantage or disadvantage to children.

Secondly, different forms of capital can be accrued; indeed, habitus is the embodiment of the accumulation of value given by the volume and composition of the different forms of capital (Skeggs, 2004). But, there may be subtle differences between parents' social positioning and dispositions towards education (i.e., family habitus), and they may also differ in the possession and desire to activate capitals (Vincent et al., 2012).

Thirdly, considering conversion of different forms of capital to one another, consciously or unconsciously (Bourdieu, 1986), accumulation will have exchange value too (Skeggs, 2004). For example, middle- or upper-class parents using economic capital to buy science-related gifts or providing their children with private education convert economic capital to cultural or science-related capital, which in turn will have exchange value and provide advantages in later life such as employability and social networks (Skeggs, 2004). In creating and exchanging various forms of capital, different people may not be able to use or exchange various forms of capital in certain settings. As Skeggs (2004) points out, culture "can be used by the middle class as a resource to increase exchange value, establishing relations of entitlement, but that same culture cannot be converted for the working class" (p.173). The middle class has access to other (e.g., working class, ethnic minority) cultures as a resource in their own self-making (Skeggs, 2004); they can enrich themselves through the consumption of ethnic diversity (Hage, 1998), and acquire valuable multicultural capital (Gibbons, 2002), whereas others who do not possess the dominant cultural capital may face exclusion, or even exploitation, with their values proving to be "use-less" (Skeggs, 2004, p.176) and with the risk of becoming residualised and positioned as excessive in the process of generating use and exchange value if they are perceived to not share White middle-class values (Reay et al., 2007).

In addition, in many outside-school science learning contexts such as science centres and museums, knowledge that counts and culture that dominates may lead to reproduction of inequalities through symbolic violence (Bourdieu, 1990), which results in non-dominant group members (ethnic minorities, working-class individuals, etc.) being at a significant disadvantage. For example, low-income minority ethnic individuals of a mix of ages and genders have been found to experience exclusion from informal science education settings (Dawson, 2014a).

While a Bourdieuian perspective is very useful for explaining students' science-related, outside-school resources and potential reproduction of inequalities in accessing these resources, Bourdieu's focus is more on social reproduction than social change (Calhoun et al. 1993), with an emphasis on pre-reflective dimensions of action (Reay, 2004; Sayer, 2004). I therefore don't receive full theoretical guidance from this perspective on how to change structurally-based dispositions and attitudes about science. In addition, considering Hays' (1994) distinction between structurally reproductive agency and structurally transformative agency, Bourdieu's discussion of agency is closer to the former, which can help us explain potential structural factors that might limit students' access or gained benefit from certain outside-school science resources, which then reproduce inequalities. However, in addition to this, I am also interested in understanding the role of structurally transformative agency in forming and modifying science attitudes and aspirations. Therefore, I need a complementary theoretical framework. Furthermore, while field provides the social contexts, there is little focus in Bourdieu on the internal content of a given field (Naidoo, 2004), which limits its use in my focus on specific outside-school factors related to science. Similarly, Bourdieu's family is functional and static (Silva, 2005) in that the process through which cultural capital is diffused and transformed is not clear: "Cultural capital's diffuse and continuous transformation within the family escapes observation and control" (Bourdieu, 2002, p.92).

In light of the above points, I next turn to Sen's capability approach which provides a helpful lens and a complementary framework in my study of outside-school factors in science education. In continuing to build my model, I synthesise Sen's critical concepts with Bourdieu's perspective, and discuss how the two approaches can enrich each other.

As an economic theory in origin with a contrasting view to existing resource-based and utilitarian approaches, Sen's capability approach does not primarily focus on resources. Instead, he prioritises capabilities, and calls those resources that are converted to capabilities commodities (Sen, 1999), seemingly with an economic undertone. A Bourdieuan view enriches this perspective by highlighting economic, social and cultural capitals, and their conversion and interactions in various fields. That is, the initial science-related resources and habitus with which a student is endowed are more than an economic commodity; rather, they are a consequence of all science-related social interactions and reproductions in the first place.

Sen's capability framework helps us distinguish between science-related resources (commodities), science capabilities and science functionings. While I acknowledge the dynamic nature of the relationships between these stages in practice (e.g., capabilities enhancing resources, or functionings helping develop certain capabilities), my model can be viewed more as a time-based explanation of capability and functioning development, such that a child may have an initial endowment of science-related capital which is acquired naturally from family environment and socio-cultural context, for example before reaching school age. This may then be converted into developed science capabilities or not, based on the existence of conversion factors which depend on the interplay between agency (deliberate specific acts such as buying science gifts) and structure (habitus, capital and field). In characterising conversion factors, structure is not necessarily static as various forms of capital can be exchanged with a use value which can provide further advantages or disadvantages to students coming from certain class or ethnic backgrounds (Bourdieu, 1986; Skeggs, 2004). However, it is not just structure and associated exchange value or use value of capitals that drive conversion factors as agency takes a more central stage in forming Sen's conversion factors, which are also affected by personal (e.g., physical condition, intelligence), social (e.g., norms, gender roles, societal hierarchies) and environmental (e.g., infrastructure, institutions, public goods) characteristics (Robeyns, 2005).

My conceptualisation of initial science-related capital is slightly different from 'science capital' introduced by Archer et al. (2014, 2015). In my model, initial science-related capital is provided to a child mostly at a pre-reflexive level without any conscious or deliberate actions, which is then transformed into capabilities and functionings through a variety conversion factors; Archer et al.'s conceptualisation seems to include dispositions as well as activities and deliberate actions. Therefore, Archer et al's (2014, 2015) 'science capital' appears to contain both science-related capital and conversion factors in my model.

Indeed, science capital (Archer et al., 2015), which draws on Bourdieu's theory on social reproduction, provides a very useful theoretical lens for explaining differential patterns of aspiration and educational participation among young people. It has been conceptualised by combining the following (p.929):

> scientific forms of cultural capital (scientific literacy; science dispositions, symbolic forms of knowledge about the transferability of science qualifications), science-related behaviors and practices (e.g., science media consumption; visiting informal science learning environments, such as science museums), science-related forms of

social capital (e.g., parental scientific knowledge; talking to others about science).

Examining these specific components of science capital as developed by Archer et al. (2015), while clearly these afore-mentioned components (e.g., dispositions, knowledge, activities) could be expected to be patterned in a socially predictable way as argued by Bourdieu (e.g., 1986), at the same time, individual agency can also help generate or enhance some of the specific components of science capital which in turn may lead to change. For example, individual/personal interest of a family member in science activities or deliberately providing children with science-related materials or activities despite limited resources (much the same way as some British Chinese parents' prioritising private tuition for their children despite their limited budgets (Archer & Francis, 2007)) may lead to an increased science participation or aspiration of a student. That is, some components of science capital and their levels may be influenced by agency despite their constrained nature by the structure. This is where incorporating Sen's capability approach in to my model can prove helpful as Sen highlights individual agency as a key during the active process of capability development. Arguably within science capital, while certain components may be less susceptible to change through agency, others could potentially be substantially affected through individual choices and actions. The use of Sen's capability approach makes this distinction clearer.

I suggest that there may be certain practices and actions outside the school that act as conversion factors of initial science-related resources to science-related capabilities. For example, parents, through conscious actions and purposeful efforts, can help their children develop science-related capabilities. For instance, parents may participate in science-related activities such as taking their children to visit science museums or working together on a science project or homework; they may buy science-related gifts, toys or magazines for their children, or simply raise their science-related awareness in daily activities or conversation.

However, science-related capability development is not a straightforward process. Although agency can help develop science-related capabilities, these are not independent of structural characteristics, inequalities and the associated reproduction process (Bourdieu & Passeron, 1990). Sen (1999, pp.11-12) pointed out this as well:

> Individual agency is, ultimately, central to addressing these deprivations. On the other hand, the freedom of agency that we individually have is inescapably qualified and constrained by the social, political and economic opportunities that are available to us. There is a deep complementarity between individual agency and social arrangements. It is important to give simultaneous recognition to the centrality of individual freedom and to the force of social influences on the extent and reach of individual freedom.

First, the existence of certain conversion factors (and related actions) may entirely depend on a certain type of capital. For example, with limited economic capital, a parent may find it an unnecessary luxury to subscribe to a children's science magazine or may not be able, due to work demands, to join a children's weekend science fair. Similarly, even if they have the personal interest, immigrant parents with limited English language skills may not get into science-related conversations with their children whose science terminology is entirely in English. Secondly, even if the conversion factor exists and related actions takes place, the benefit that may be received from it and the subsequent capability development may be significantly inhibited as a result of habitus and cultural and social capital. For example, even when economic capital is not an issue, individuals from minority ethnic backgrounds may get a 'not for us' feeling on museum or science centre visits (Dawson, 2014a). Similarly, families with greater pre-existing cultural and social capital and with a better alignment of their own habitus and institutional habitus may derive higher and wider exchange value from museum visits with compare to families who lack such capital and alignment (Archer et al., 2016). Finally, considering the significance of field in converting science-related resources to capabilities, certain families can provide a more conducive field for their children to develop science-related capabilities (e.g., private schooling, living in a well-off neighbourhood with many people in science careers), whereas some students may experience fields that are highly unfavourable for science learning (e.g., a girl living in a family in which science careers are only associated with men). To sum up, because the capability approach largely focuses on individuals, their freedom and choices, and there is not much mention of social structures (Stewart, 2005), its reach and significance can be substantially improved by incorporating Bourdieu's emphasis on habitus, cultural and social capital and field.

Next, it is important to remember Sen's distinction between capabilities and functionings. A child, for example, may develop certain science-related capabilities, but these may not necessarily translate into science-related functionings. Some students may develop an excellent set of science-related capabilities, but with their freedom and meaningful reflection, they may decide not to convert these capabilities to functionings. In my model (Figure 3.1), science-related functionings can take the form of career aspirations or other related outcomes. An important aspect of my model is that there are certain factors that help convert science-related capabilities to science-related functionings. These may include efforts to make science-related careers appealing, showing good role models in science, demonstrating the exciting, and relevant side of science, etc. Thus, I propose that there are two types of conversion factors. The first set of factors convert initial science-related capital to science-related capabilities, whereas the second convert science-related capabilities to science-related functionings.

Before concluding this chapter which outlines my theoretical approach and introduces my model, I discuss how combining Bourdieu and Sen can provide original theoretical guidance to my study.

Bourdieu provides a strong and convincing account of social reproduction of inequalities (Collins, 1989; Wacquant, 1987) by highlighting both the unequal distribution of structurally-based resources (capitals) and the interaction between economic, social and cultural capital in everyday life through which the interaction process contributes to the reproduction of social inequalities (Bourdieu, 1984). This perspective is highly useful in explaining the availability of outside-school science-related resources to students, their access to such resources, and ultimately the influence of these on students' science participation. In addition, Bourdieu's account of the conversion, accumulation and transmission of different forms of capital provides a useful lens for understanding students' formation of structurally-based dispositions and attitudes about science.

However, beyond simply acquiring or consuming science-related resources, in order for science-related capitals to help enhance science participation, individuals (students and parents) need to actively use them through agency. That is, the active acquisition, accumulation and use of various forms of science-related resources (capitals) depend on parents' and their children's agency. Yet, because Bourdieu's focus is not on explaining social change but rather on social reproduction (Calhoun et al., 1993) and unconsciously internalized dispositions (King, 2000; Reay, 2004), I receive limited theoretical guidance from Bourdieu on how, through agency, parents and children may change or modify their structure-based attitudes and aspirations about science, how some outside-school factors may potentially provide opportunities for such changes, and how parents' choices and actions might contribute to changes in students' science-related dispositions.

In addition, although Bourdieu's framework can help us understand equity and inclusion issues in science education by focusing on the role of structural factors that might limit students' access or benefit from certain outside-school science resources, it may be limited in explaining transformation of certain structure-driven science attitudes and aspirations. Furthermore, while Turkish families and associated cultural capital are a key focus in my study, in Bourdieu's work, family is mostly functional and static (Silva, 2005) in that the process through which cultural capital is diffused and transformed is not clear: "Cultural capital's diffuse and continuous transformation within the family escapes observation and control" (Bourdieu, 2002, p.92). As a result, a Bourdieuian perspective may have limitations in helping us understanding how families can change students' science-related choices, decisions and attitudes.

Sen's capability approach provides a helpful lens and a complementary framework to Bourdieu's concepts in that it not only brings an additional focus on capabilities and agency in students' development of science attitudes and aspirations, but it also explicitly accounts for conversion factors which can be personal, social or environmental (Robeyns, 2005). In addition, a capability approach emphasizes the agency role of the individuals for bringing change to their daily lives and realizing their full potential. Therefore, the agency- and capability-based perspective of Sen can play a key complementary role to Bourdieu's framework in explaining how children's structured dispositions and attitudes for science might be not only constrained and reproduced but can also be transformed and changed with outside-school factors such as parental actions.

On the other hand, because the capability approach largely focuses on individuals, their freedom and choices, and there is not much mention of social structures (Stewart, 2005), the reach and significance of Sen's capability approach can be substantially improved by incorporating Bourdieu's emphasis on habitus, cultural and social capital and field.

Although Bourdieu's key concepts such as habitus allows for individual agency, it also "predisposes individuals towards certain ways of behaving" (Reay, 2004, p.433); as such, his concepts offer limited guidance for explaining action and the dynamics of change (Swartz, 1997). Indeed, Reay (2004) highlights Bourdieu's focus on pre-reflective dimensions of action and Sayer (2004) suggests that by focusing "below the level of consciousness" (p.73), Bourdieu (1990) may be neglecting the significance of mundane, everyday reflexivity. Similarly, Crossley (1999) criticises Bourdieu's lack of emphasis on reflective and creative aspects of practice. In fact, Bourdieu indicates that his interest lies in habitus as a way of explaining reproduction and not with the dynamics of specific 'organisms' (Bourdieu, 1977; Noble & Watkins, 2003). Consequently, Bourdieu's concept of habitus does not really include Sen's notion of capability which is the ability to achieve desired functionings through action and by bringing about change. That is, with its explicit focus on individual agency which is at the centre of addressing deprivations and its emphasis on the way actions and choices bring about change, Sen's capability approach provides additional theoretical guidance to help us understand dynamics of changes in students' development of science attitudes and aspirations.

To sum up, in seeking theoretical guidance to address my research questions on Turkish immigrant students' science participation, Sen's capability approach provides an action- and change-based perspective to Bourdieu's structure- and explanation-based perspective. In this way, by combining these two approaches when studying the role of outside-school factors on Turkish children's formation of science attitudes and aspirations, I am able to incorporate familial agency while at the same time highlighting their dependence on structural factors.

4 Chapter Four: Methodological perspective and research design

This chapter describes ontological and epistemological stance undertaken throughout this research, explains the methods used and discusses methodological issues that are raised by the chosen methods.

4.1 Epistemological and ontological approach: Critical realism

Critical realism, which has its roots in the writings of Roy Bhaskar (1978; 1989; 1998), is an increasingly influential post-positivist approach in the social sciences (Archer et al., 1998; Collier, 1994; Danermark et al., 2002). Critical realism is an alternative paradigm to positivist and interpretive/constructionist approaches, with a strong focus on ontology. It argues, first, that objects in the natural and even the social world exist whether the observer or researcher is able to know them or not, and, secondly, that knowledge of these objects is always fallible because while describing them one should take into account the transitive nature of knowledge (Scott, 2007), that is, “artificial objects fashioned into items of knowledge by the science of the day” (Bhaskar, 1998, p.11).

Archer (1995) suggests that a social system consists of interplay of structural emergent properties, cultural emergent properties, and people’s emergent properties; and while there are observable outcomes that characterize change, these depend on a complex interplay of the three emergent properties. “The role of theory in social science therefore is to interpret empirical phenomenon in terms of how observed events are the contingent outcomes of the interaction of unobservable processes.” (Cruickshank, 2011, p.8). In this sense, critical realism does not agree with the view that there is some absolute truth or reality by which various objects or accounts could be compared or contrasted (Maxwell, 1992). Critical realism acknowledges the existence of conceptual, physical as well as social objects of knowledge.

Although critical realists point to the generalizing task of scientific activity, similarly to positivists, unlike the positivist approach, critical realism’s focus is not to identify predictable patterns but, instead, to identify deeper underlying mechanisms that generate empirical phenomena. This is basically a major shift from epistemology to ontology, and a shift from events to mechanisms (Alvesson & Skoldberg, 2009). An important criticism of critical realism of other philosophical approaches is that is their focus is on epistemology rather than ontology. Bhaskar (1997) argues that this is problematic, because they commit the ‘epistemic fallacy’ of translating ontological questions about what reality is into epistemological questions about how we gain knowledge of reality.

Critical realism distinguishes between three domains of reality: the ‘real’, the ‘actual’ and the ‘empirical’. The real includes events and experiences, and the underlying structures, mechanisms, and relations. The structures, mechanisms, and relations generate events and behaviour in the social world. The actual consists of these events and behaviour that actually emerge, whether observed or not. And finally, the empirical is the one that we observe or experience (Bhaskar, 1978). According to critical realism, scientific work should “investigate and identify relationships and non-relationships, respectively, between what we experience, what actually happens, and the underlying mechanisms that produce the events in the world” (Danermarket et al., 2002, p.21).

In my research, which examines the role of outside-school factors in science education, I try to explore mechanisms that lead to varying levels of aspirations and attitudes in science. Unlike a positivist approach, which tries to establish exact, specific, and universal causes and effects, I acknowledge that relations are complex and causality is contextual and emergent, which is very much in line with the critical realist approach. In addition, although I am interested in synthesis and context with regards to the role of outside-school factors, which is similar to constructionist or interpretivist approaches, my critical realist approach diverges from these viewpoints in the sense that I believe that there exists certain objects and generative mechanisms related to specific outside-school and parental factors that would cause different science attitudes, capabilities and aspirations of students independent of me as a researcher or my ability to know and identify them.

In order to address my research questions, with a critical realist viewpoint, I have undertaken a mixed-methods approach. Scott (2007) suggests that critical realism could suggest a coherent solution to the quantitative-qualitative divide at the ontological level. Critical realists consider the research process as a constant digging in the ontological depth of reality (Alvesson & Skoldberg, 2009). In the same vein, my goal with my research study is to dig deep underneath the surface of the role of outside-school and parental factors in students' science-related capability formation and expansion, and explain the detailed mechanisms associated with it. To achieve this, I employed a mixed-methods approach by conducting surveys and interviews supported by some in-class observations, in which each one of these methods informed and fed on others. I provide the details of these in the next section.

4.2 Introduction to methodology: Mixed methods approach

I have designed and used a mixed-methods approach in my study. In the following sections, I first outline and discuss my methodological approach, and then provide an explanation of each method I use by discussing the reasons for these choices as well as their implications for my research.

Mixed methods research is defined as:

> the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purpose of breadth and depth of understanding and corroboration (Johnson et al., 2007, p.123).

Both quantitative and qualitative research has its own support by researchers pointing out their unique strengths. For example, quantitative researchers point out that measurement allows us to "transcend our subjectivity in a way that open-ended data and analyses do not" (Bradley & Schaefer, 1998, p.108), on the other hand, qualitative researchers suggest that "qualitative methods are more faithful to the social world than quantitative ones, as they allow for data to emerge more freely from context" (Gergen & Gergen, 2000, p.1027). In educational research, mixed methods research is becoming a prevalent methodology as it brings together the strengths of both methodologies.

Some of the advantages of mixed methods research can be summarized as follows (Creswell & Clark, 2007): First, by combining quantitative and qualitative methods, mixed methods research could provide a strong methodological framework by offsetting the potential limitations of each of these methods. Secondly, when studying a research problem, mixed methods research could provide a more comprehensive evidence as researchers are not restricted to rely on one method. It is also practical because the researcher is not limited and could use all possible methods available to address a research problem. And finally, mixed methods research could address questions that cannot be answered by qualitative or quantitative approaches independently. For example, when a researcher wants to contrast or compare participants' interview and survey responses, or tries to qualitatively explain the quantitative results of a study, mixed methods research is the ideal choice. Despite these potential advantages, mixed methods research comes with its own challenges (Bryman, 2007; Johnson & Onwuegbuzie, 2004). In addition to compatibility issues associated with two different paradigms and required technical skills to conduct both types of research, a main issue is the integration of two different types of data. Because qualitative and quantitative data are quite different in nature, a meaningful integration and joint interpretation of them can be difficult. But this is critical, as the primary goal of mixed methods approach is to enrich our understanding by combination of different types of data.

In my research where I investigate the significance of outside-school factors on Turkish minority students' attitudes and participation in science, I decided to use mixed methods for several reasons.

First, because my research is about outside-school factors especially related to families, the need for a qualitative approach is quite clear. By interviewing both students and their parents, I can get detailed and rich information about the role of parents in shaping students attitudes and aspirations in science. However, since my research question is specifically about Turkish immigrant children, and these children can be in different educational settings in the UK (in a Turkish independent school, in a maintained British school, etc.), I want to collect comparable data across these. In addition, I also want to contrast these data with Turkish children living in Turkey. Therefore, a survey would be ideal to collect common data from these different sources.

Secondly, in my research, I develop a new theoretical framework that combines Amartya Sen's capability approach and Bourdieu's habitus and cultural capital in examining outside-school factors in science education. Consequently, I develop and use several new constructs which are not easy to get information with one method only. For example, apart from the practical difficulties of getting survey responses particularly from parents, it will be very hard to get data about parents' or students' attitudes towards science or about cultural contexts and link them to my theoretical framework by just conducting a survey alone. Similarly, it will be hard to quantify or contrast different parental and cultural factors if I only collect qualitative data.

Thirdly, my research questions are about both observable and unobservable factors in science education. For example, regarding students' aspirations in science, with a mixed-methods approach I can get both observable and objective data from surveys (e.g. their answers to survey questions about science aspirations), and unobservable data such as what their parents feel and think about science, what are their aspirations, through interviews. Because both of these factors are important and highly relevant to my research questions, I decided to pursue a mixed methods approach.

And finally, combining quantitative and qualitative approaches strengthened my study and help address potential weaknesses. For example, my sample size from the survey was not very large since my data were collected from two schools in the UK and five schools in Turkey. Also, my interviews with students, parents and teachers may not cover the whole range of attitudes towards science and science education. But, with a mixed method approach that combines interviews and surveys supported by some in-class observations, I addressed my research questions rigorously and more effectively.

Considering the challenges associated with a mixed methods approach discussed earlier, in my study I carefully integrate my quantitative (survey) findings with my qualitative findings. Specifically, after presenting each of my quantitative findings in Chapter 7, I bring in related findings from the interview analyses from Chapter 6 and include a discussion of the overall results in light of both types of data. This way, the different types of empirical data complement and enrich each other and jointly provide a better understanding of the role of outside-school factors in Turkish immigrant children’s science-related capability and functioning development.

In my study, I also, in Chapter 8, employ comparative analysis to make comparisons between Turkish immigrant children in the UK and Turkish children in Turkey in terms of science-related resources and science-related capability and functioning development. At a broader level, ‘comparative research’ is the comparison of specific issues or phenomena in two or more countries, societies or cultures where the goal is to systematically study and compare manifestations of phenomena in more than one spatial or temporal sociocultural setting using the same research instruments (Halls, 1990; Hantrais, 2008). While the field of comparative education research is vast (Crossley & Broadfoot, 1992; Bray & Thomas, 1995; Bray, Adamson & Mason, 2014), in my study I use a comparative approach as a follow-up to my analyses of the UK data. Because the immigrant identity of Turkish parents and their children, and associated factors, play an important role in my study, in order to better understand this critical element, I compare science-related resources and capability and functioning development between Turkish students whose parents moved to the UK and Turkish students who remained in Turkey. While I realise that in-school factors are likely to be different in the two countries, these students, and particularly their parents, are likely to share many cultural and socially based dispositions and attitudes towards science. Therefore, after considering country and system-based differences, in the two countries students’ differences in their science-related capability and functioning development could be at least partially attributed to ‘immigrant identity’ and associated factors. This approach has been used and recommended in previous migration studies where migrants who move internationally are compared with people who stay in the place of origin (Fitzgerald, 2006; 2012).

In the next section, I first give an overview of my data collection steps. I then discuss each one of my data collection approaches in detail. For each, I first provide the reasoning for this approach, and then outline the specific steps I have undertaken while collecting data.

4.2.1 The use of interviews

As described in the previous chapter, the theoretical framework I develop in my thesis in studying the role of outside-school factors on Turkish immigrant children's science participation combines Bourdieu's structural reproduction theory with Sen's capability approach. A key premise of this theoretical framework is that students' science participation is the product of the interaction between structures and agency in that while familial resources and choices available to students may be somewhat constrained by structure, agency and conversion factors still can play a significant role in children's development of science attitudes and aspirations. Accordingly, combined with the critical realist perspective taken in this research, my research design, which employs semi-structured interviews and a survey, takes into this interaction. As Scott (2007, p.15) points out: "accounts which focus on either structures or agents to the exclusion of the other cannot account for the totality of the social experience, and it is the interaction between the two which needs to be the focus of the research".

A major component of my research methods is interviews, through which I explore outside-school and family contexts as well as the understandings and rationales of Turkish children in relation to forming their science attitudes, aspirations and choices. Parent interviews complement children interviews by not only providing their own perspective, but also giving an enriched contextual account in relation to students' science participation (Legard et al., 2003). That is, through interviewing parents, different family contexts are brought to light. Additionally, teacher and school staff interviews provide perspectives on Turkish immigrant students' science participation, and their account of potential inside- and outside-school factors.

The interviews were all semi-structured; that is, I had an initial set of themes to be explored and prepared an initial set of questions. This allowed for some consistency and comparability across the interviews (Arksey & Knight, 1999). At the same time, the semi-structured nature of the interviews provided flexibility, openness to new issues raised and space for unexpected contributions from the participants (Robson, 2002).

Overall, in comparison to more involved and costly (in terms of time) data gathering techniques, such as ethnographic research, interviews helped me obtain a significant amount of material in relation to Turkish students' science participation effectively (Bryman, 2008). They were also relatively uncomplicated and invasive from the schools', students' and parents' point of view. In addition, in order to make sure that as the researcher I was not entirely deprived of the ethnographic context in which the participants reported perceptions occurred (Burns 2000), I conducted some parental interviews in the parents' home, which helped me more directly observe parents in their everyday context, and also conducted in-class observations of science lessons.

Having said this, the interviews had their challenges and limitations. First, since part of this research was exploratory, I wanted to give significant space to interview participants to allow for 'surprises' and to elaborate on issues that they felt were important. While this was more possible with the parental interviews, some of which took place in their homes or in a coffee shop, due to time limitations, especially in a busy school environment where teachers have many commitments, I did not get a chance to follow up and explore more deeply on some interesting points raised in the teacher interviews. Similarly, in order to ensure that I strictly adhered to student interview schedules, perhaps some issues raised were not as deeply explored as they could have been. An example of such a limitation is teachers' and some parents' very interesting comments on the role of some cultural practices and religious views (e.g., girls' early marriage, parents' views on evolution) which were not further explored during student interviews due to time constraints. While the scope of my work did not allow me to explore such issues in greater depth, these could be explored in future research.

Secondly, teacher and staff interviews were conducted at school, most student interviews were conducted in an available room in the school, and parental interviews took place in their preferred location (e.g., their home, school office, a coffee shop). As Kvale and Brinkmann (2009) point out, there is a physical aspect of the interview in that it involves the meeting of two people in a specific space, which might have implications. For example, having the interviews in a formal education space, at school, might have made some students more reserved during the interviews (despite the interviewer sharing many similarities with them, i.e., being a Turkish woman who grew up in Turkey and has been living in the UK for less than ten years) or affected some of their responses about science attitudes and aspirations. However, an advantage of school interviews in comparison to home interviews could be that students might have felt more comfortable discussing issues related to home and family.

The validity of data obtained through interviews is not easy to assess, especially when young people are involved. Some of their statements may be contradictory, their personal narratives may not fit together or they may conflict with apparent realities (Kvale & Brinkmann, 2009). Being mindful of this, especially during student interviews, I tried to follow up with clarification questions when I felt such contradictions might be taking place. Similarly, when social actors who may be constrained by social structures are involved in interviews, they may be trapped in a 'false consciousness' (Meyerson, 1991; Yeung, 1997), unable to realise the full situation or articulate the full account of their perceptions or actions. In order to address this, I tried to follow Brinkman's (2007) idea of the 'epistemic interview', and instead of being an entirely passive participant in the creation of meaning, I tried to at least clarify as much as possible the statements where I suspected this might be happening. In addition, following the guidelines of Kvale and Brinkmann (2009), I avoided trying to maximise the private information extracted from the participants through inappropriate means such as faking admiration, sympathy or approval.

The translation process is important for the validity of interviews undertaken in one language and reported in another. Before interviews, as a bilingual interviewer, I offered all parent participants to choose the language (Turkish or English) in which they would feel more comfortable doing the interview and also asked them to feel free to switch from one to another whenever they wish during the interview. Most of the parents chose Turkish for the interviews. After completing verbatim transcriptions, I first worked on these transcriptions in their original language. I found this more productive and it was easier to appreciate some of the more complex points raised by the parents. This helped me not to miss nuances and some deeper insights and details that might have been lost after translation. After re-reading my notes and doing the initial analysis, I first attempted to get all the interviews translated into English by a professional (certified) translator of Turkish origin. However, after getting some initial translations, I quickly realised that the translations were not adequately capturing the depth of the nuances that were hidden in the conversations due to the translator's lack of contextual knowledge. In addition, the word choices in this professional translation were mostly quite formal and dry, limiting the richness of the expressions by the parents. Consequently, I made all the interview translations myself and then received advice and assistance by a professional certified translator, who is also a personal friend, to review and revise my translations. After incorporating her revisions and suggestions, and completing the translations, for each interview I then compared the original interview transcripts with the translations for accuracy and consistency.

A data limitation for my study is that, while I was hoping to gather empirical data in Turkey through interviews, I was not able to conduct formal interviews in Turkey due to time limitations. As a result, I only hold informal conversations. As part of my fieldwork in Turkey, when I first contacted schools, I sent them the outline of my research (information sheet) and consent forms for schools. After arranging appointments with school headteachers and some science teachers in multiple schools in Istanbul, during my initial visits, I had informal conversations with them about my research and data collection plans. During these conversations, most of them generously shared their views and observations about students' science interest, capabilities, and aspirations. However, as I was not able to arrange and conduct formal interviews due to the limited duration of my stay in Turkey and teachers' busy schedules, the initial casual conversations stayed as informal exchanges and I did not use them as data in any part of the thesis. However, they helped me in my interpretation of the survey findings in Turkey.

4.2.2 The use of questionnaires

In my study, the survey is a way of collecting complementary data and providing accessing to another level of analysis on the role of outside-school factors for students' science participation that would not be possible with interview data alone.

Some researchers have been highly critical of surveys as a research tool. For instance, Robson (2002, p.231) states: "the findings are seen as a product of largely uninvolved respondents whose answers owe more to some unknown mixture of politeness, boredom and a desire to be seen in a good light than to their true feelings, beliefs or behaviour". Sayer (1992, p.177) points out that: "context-dependent actions or properties such as attitudes might therefore be considered unsuitable for quantification. If we do insist on quantifying them, we should at least be extremely wary of how the results are interpreted".

However, I believe the very nature of surveys, being impersonal and distant, could be valuable in reflecting accurate views of the participants as they are less prone to the discursive consciousness that may take place during interviews (Vaisey, 2009). Carefully constructed forced-choice surveys can tap into automatic, unconscious or semi-conscious schemas held by the participants. Especially for the young persons involved in my study, who may have difficulty in consistently articulating their views and experiences in a short period of time during interviews (Kvale & Brinkmann, 2009), I believe the survey provided an opportunity to more freely and perhaps accurately present their thoughts and actions.

Also, in my study, I argue that quantification through the survey gives me access to a larger set of data and different analysis tools which would otherwise not be possible by the interviews alone. Overall, I concluded that the survey was a very useful tool to complement my understanding of context-dependent patterns of Turkish students' science capability development by collecting data from two different schools in London as well as from several schools in Istanbul.

I should also acknowledge some of the limitations of my survey and raise certain validation concerns. For example, for some questions (such as ethnic self-concept, Table 7.1), students' responses are greater for the choice 'neutral' in the five-point Likert scale in comparison to others. It may not be clear whether these respondents are indeed neutral to the question and have average feelings, or if they pick this due to some confusion or ambiguity (Andres, 2012).

Also, some of the questions in my survey asked students' view on their parents' interests or attitudes towards science, among others. Such questions are more subjective than other more factual questions about their families in the survey as they probe students on their views of their parents' opinions (Appendix 15 provides a copy of the survey). While admittedly students' responses on such questions may not be fully accurate or may not reflect reality fully, I believe there is value in extracting and analysing such information. After all, my research investigates outside-school factors in students' science capability development, and to some extent, how students perceive their parents' attitudes may be as important, if not more important, than the actual attitudes and opinions of their parents.

Another potential concern for the validity of survey is the translation process as I conducted student surveys in Istanbul with the Turkish translated versions. I completed the translations myself but I also sought advice and then had them checked and revised by a science teacher in Turkey who is bilingual in Turkish and in English. In fact, initially my plan was to have all questionnaires be translated into Turkish by a professional translator. However, rather as with the interview transcripts, I quickly realised that this translation was highly complicated from the students' perspective and unsuitable for my purposes, since a successful translation required familiarity with both the Turkish educational context and my particular study.

During translation of the questionnaire into Turkish, I tried to choose the right words for common usage in educational settings in Turkey and for ease of understanding by Turkish students. To get a better sense of the vocabulary used, I first checked academic papers published in Turkish education journals which had conducted questionnaires in the field of science and science education. For example, for the word of 'science', there are multiple different translations into Turkish, which are used in different contexts and purposes. Science can be translated as 'bilim', 'fen' or 'fenbilgisi', 'teknik' and 'ilim'. But all of these have some contextual use. After getting insights from academic papers and recent reports on science education by the

Turkish Education Ministry to identify the most appropriate use of words, I translated the original questionnaire into Turkish myself. I then asked a bilingual colleague who works as a science teacher in Turkey to check and revise my draft translation. After incorporating her suggestions and revisions, I then finalised the Turkish version of my questionnaire.

4.3 Sampling and data collection

I took a purposive sampling approach in my study (Patton, 2002; Silverman, 2010) since my aim was to focus on a specific group of people in my research (i.e., Turkish minority students in the UK). In addition, because I was interested in the role of outside-school factors, particularly in relation to families, for my research purposes, I tried to include in my sample (both for qualitative and quantitative study) a heterogeneous set of Turkish minority students and their parents in terms of socio-economic status, science attitudes, aspirations, and capabilities. I achieved this in two ways: First, I conducted my study both in a maintained school and in an independent school in London. Secondly, in my student and parent interviews in both schools, with the help of my own in-class observations and teachers at these schools, I included a diverse set of Turkish students and parents in my interview sample.

I collected data in three stages. First, I collected data about Turkish immigrant children from an independent school in London. Secondly, I collected similar data from a maintained school in London with a significant Turkish minority student population. And thirdly, I collected data from five comparable schools in Istanbul, Turkey.

There were several reasons for my choice of two different schools in London for my data sources. As my research questions were about students' science attitudes and participation, and I am particularly interested in outside-school (e.g., family-related) factors, I wanted to reach out to a diverse set of immigrant Turkish students with various family backgrounds. For example, in the independent school, students pay a tuition fee, whereas maintained school does not charge a fee to students. So, parents in these schools typically have quite different socio-economic status. Also, the independent school has a small student population, the majority of parents in the independent school are Turkish, and the school makes an extra effort to work closely with these parents. This was not the case in the large maintained school. In addition, I wanted to explore the role of outside-school factors, so I want to make sure that students' attitudes or aspirations in science were not driven only by a specific in-school factor such as a highly successful (or unsuccessful) school, a science department, or a teacher. To ensure this, I needed to collect data from more than one school. And finally, in order to gain deeper insights on the role of being immigrant on students' science attitudes and aspirations, I decided to collect data from Turkey as well. This would help me identify any 'immigration'-related issues, and compare students' science capabilities and functionings both in the UK and in Turkey.

Next, I outline my data collection steps and research sites.

4.3.1 Athenaeum school

First, I collected data from a Turkish independent school, Athenaeum school, in London. Athenaeum school was a non-denominational and co-educational day school. The school had a total of 82 students, and 12 teachers. Annual school fee at the time of data collection was £6,750. In the most recent OFSTED inspection, the school was identified as a 'Good' school with inspectors commenting, "the quality of teaching and assessment is good, and pupils make good progress. Pupils' spiritual, moral, social and cultural development is outstanding due to the school's emphasis on this aspect of its work and the family-like ethos of the school." The school has 95% achieving A*-C in English and maths GCSEs, and 91% (2011) and 74% (2012) achieving 5 A*-C GCSEs (or equivalents) including English and maths. I first conducted preliminary in-class observations for Year 7 and Year 10 science lessons. These were followed by the student survey. Next, I conducted semi-structured interviews with teachers, selected students, and parents.

Overall, my experience as a researcher was very positive at the Athenaeum School. After communicating my research goals and explaining how my study could help

Turkish minority students in multiple ways, both management and teachers at the Athenaeum School were very supportive of my research throughout the study. Also, as a relatively young school, I think the school management (who were all of Turkish origin) felt quite pleased and perhaps even proud for being part of a PhD research project that focusses on Turkish minority children in the UK and that is conducted by a PhD student of Turkish origin. In addition, being a small school, after multiple visits, I was already familiar with most staff members. Overall, I felt that the administrators and teachers believed that I am doing a valuable service to the Turkish community in the UK, and I felt very welcomed throughout. Also, despite their extremely busy schedules, they not only participated in my teacher interviews, but they were also very helpful in putting me in touch with the parents.

4.3.2 ANS school

In the second stage, similar data collection was conducted from a maintained school in London which had a high population of Turkish students. In order to find a suitable maintained school for my study, I identified all large secondary schools in several London boroughs with notable Turkish population (e.g., Haringey, Hackney, Enfield, Southwark). I then sent an email to their Headteachers and Head of Sciences with an outline and my proposal to conduct research at their school. Three schools positively responded to my email, after several email exchanges and meetings with them to discuss the feasibility of my requests, one school, ANS, agreed to my research study.

My experience was also very positive from start to finish of my data collection at the ANS school. Here, the school's Head of Science Mr Ilbert was instrumental in granting me access to the school, and helping me arrange questionnaires with Turkish minority students and conduct interviews with science teachers. Mr Ilbert had a master's degree from the same institution that I am conducting my doctoral research with [Institute of Education], and my impression was that he also had a genuine belief and interest on educational research. These, combined with his efficient style, my research experience at the ANS school was also very positive.

ANS was a large than average-sized secondary (maintained) school established in 1982 in London. This school had a higher than average proportion of students eligible for free school meal. The proportion of students from minority ethnic backgrounds was also well above the national average at the ANS School. In the most recent OFSTED inspection, ANS was also identified as a ‘Good’ school with inspectors highlighting: “Achievement is good and rising. The vast majority of students make at least the nationally expected rate of progress. Staff are exceptionally successful in creating harmonious relationships with all students. Students have positive attitudes to learning. They say they feel very safe in school, are proud of their school and are very well cared for. Parents overwhelmingly support this view.” Similar to Athenaeum School, I first did in-class observation of science lessons, followed by student survey and then semi-structured interviews with teachers, students and parents.

4.3.3 Schools in Turkey

Finally, in the third stage, I collected data from five schools in Istanbul, Turkey to compare and describe how science attitudes and capability development process may differ between Turkish students living in Turkey and those in the UK. Similar to the UK, for my survey in Turkey, I had a mix of maintained schools (three) and independent schools (two). Also, to increase consistency and comparability of this analysis, because the two London schools in my survey had OFSTED ‘good’ ratings, I chose schools in Istanbul which have good profiles. While there are no official ratings of schools in Turkey, based on my discussions with local educational administrators in Istanbul, I picked schools which they described as ‘good’ which were above average but not outstanding compared to other local schools. I identified and got in touch with these schools mostly through personal contacts who knew administrators of these schools.

Also, while I was able to fully conduct surveys at schools in Turkey, due to time limitations of my visits to Istanbul, Turkey, the lengthy process (e.g., receiving consents etc.) of involving parents and students to interviews, and time pressure for teachers at schools, I was not able to conduct interviews. Instead I only hold informal conversations with a few teachers, and personally known parents and students without audio recording. These casual conversations were not used in any part of the thesis other than helping me in more effectively interpreting the surveys.

All original documents I prepared in English such as questionnaire information, parents' consent forms, and actual survey instruments were translated into Turkish by myself with the assistance of a science teacher colleague in Istanbul (who is also proficient in English) to make sure I used the correct science-related terminology and vocabulary in Turkish. Similarly, all data collected in Turkish were translated into English by me.

In the next section, I discuss the rationale and details for each of my research methods followed by data analysis.

4.4 Research methods

Before providing the details of my research methods, for ease of reference, I provide a summary of my research approach, data and analytical approach in Table 4.1 below.

Table 1.1: Summary of research approach, data and analytical approach

<table>
<tr><td>Ontology</td><td>Critical realism</td></tr>
<tr><td>Methodology</td><td>Mixed-methods research</td></tr>
<tr><td>Use of theory</td><td>Pierre Bourdieu (habitus, social and cultural capital, field)
Amartya Sen (capability approach)</td></tr>
<tr><td>Research Tools and
Data</td><td>In-class observation: 20 hours (ANS, Athenaeum, Turkey)
Semi-structured interview: Summary of interview participants
<table>
<tr><td></td><td>ANS</td><td>Athenaeum</td><td>Total</td></tr>
<tr><td>Students</td><td>6</td><td>10</td><td>16</td></tr>
</table>
</td></tr>
</table>

	Parents Staff	7 5	4 2	11 7
				Total: 34
	• **Survey**: Summary of survey participants			
		ANS	Athenaeum	Turkey
	Students	42	51	383
				Total: 476
Sampling	• Purposive sampling			
Analysis	• Qualitative: Constant-comparative technique • Quantitative: Univariate analysis ○ One-way ANOVA ○ Kruskal Wallis ○ Post-hoc Bonferroni			

4.4.1 In-class observations

Although my research was primarily about outside-school factors on students' aspirations and attitudes in science, I needed to get a sense of students' varying degrees of interest in science both inside and outside the classroom. This also helped me for becoming familiar with the students as well as the school context. That is why I started by conducting in-class observations of students in science lessons.

As one of the goals of my study was to better understand the formation of individual students' attitudes and aspirations in science, the classroom was the first place to investigate this. Several researchers have examined students' experience in school science lessons over a long period of time. Shapiro (1994) investigated children's learning of the physics of light by attending science lessons and relating what they know to their personal characteristics (whether they are bored with science, whether they think about science outside the school). Hellden (1998a; 1998b; 1999) studied a group of students' understanding of biological processes by observing them over a decade. Reiss (2000) conducted a five-year longitudinal study of mixed ability students by observing them in class from their beginning of year 7 to end of year 11, and investigated two main research questions of (i) how pupils experience school science lessons and (ii) why some pupils enjoy science and do well in it.

With in-class observations, I achieved several goals for my study. First of all, as mentioned earlier, my research was about the role of outside- school factors on students' attitude and aspirations in science. During in-class observations, I learned important insights on students' attitudes about science topics and lessons. I also observed which students showed a more genuine interest during the science lesson, which students were easily bored, how attentive they were to various science topics, etc. Since I conducted in-class observations first (before getting any information about specific students' attitudes or career aspirations), I was able to get students' attitudes towards science without any preconceptions. Combining these observations with my student and parent interviews, I was able to link various interview responses to student attitudes in science lessons. Secondly, although my main research questions were about outside-school factors, I still wanted to identify and observe major in-class factors that might have affected students' attitudes and aspirations. If a certain attitude or aspiration was directly related to an in-class factor, by identifying this in-class factor early in my observations, I would have gotten a clearer picture of potentially related outside-school factors. And thirdly, I got a very good understanding of the research context during these observations and they helped me better prepare for the interviews. After observing students and teachers in class, my student and teacher interviews were much more effective. Both students and teachers already knew about me, I already knew about them, and I was able to better relate my interview questions to them.

I made a total of 20 hours of in-class observation of science lessons in the two schools in London and in the five schools in Istanbul. I was a passive observer in these classes, sitting at the back of the classroom, and observing Turkish students' interactions in science classes. I took detailed notes during my in-class observations. Although I did not analyse these notes individually, they were very helpful for me to better prepare for staff, student, and parent interviews, and to enrich the insights I obtained from them.

4.4.2 Questionnaire/survey

I collected data through a survey from three different schools: an independent Turkish school in London (Athenaeum), a maintained school in London (ANS) with a large Turkish population, and five schools in Turkey. See Appendix 15 for details of the survey. Survey data and analyses helped me in my research in several ways. First, with compare to a qualitative approach such as student interviews only, I was able to reach to a larger number of students with the survey, and captured a good amount of heterogeneity between students. Secondly, because research sites in my study included different types of schools (maintained vs independent) and from two different countries, collecting quantifiable data with the survey was helpful for me to more easily compare and contrast my results across different schools in my study. Thirdly, there was already a good amount of survey-based work that examined students' attitudes or aspirations in science (see for example Archer et al., 2013; Aschbacher et al., 2010; Dewitt et al., 2011; Lindahl, 2007; Tran, 2011). These were not only helpful in my survey design, but also in my survey analysis and interpretation to compare and contrast to what extend my findings were similar or different to the findings in these papers. And finally, my survey results informed me in the development and conduct of my semi-structured interviews. After obtaining some initial insights and observing some interesting relationships from the surveys, I was then able to focus on these issues in more detail during my interviews and tried to understand the mechanisms resulting in these observations.

4.4.2.1 Questionnaire design and piloting

In developing my survey instrument, I decided to build on previously developed and validated instruments where possible. I also used constructs that have well established theoretical and empirical validity. My measures relating to student attitudes and aspirations were primarily drawn from the following studies: ASPIRES students' aspirations survey (Dewitt et al., 2010), 'Is Science Me?' survey (Gilmartin et al., 2006), 'The modified attitudes toward science inventory' (Weinburgh & Steele, 2000), the 'Science Motivation Questionnaire' (Glynn & Koballa, 2006) and the 'Science Opinion Survey' (Gibson & Chase, 2002).

For the remaining constructs that I originally developed, such as science capability, parental science activity, cultural activity, role model visibility, among others, I developed items by carefully establishing their reliability and construct validity including internal consistency as well as uni-dimensionality. The most common way to test the reliability of survey scales is to calculate Cronbach's alpha coefficients (Cronbach & Shavelson, 2004). Cronbach's alpha is a measure of internal consistency which refers to the interrelatedness of a set of items. Because this measure does not consider homogeneity, one needs to be cautious in relying on Cronbach's alpha (Schmitt, 1996). As a result, in addition to calculating Cronbach's alpha scores for my measures, I also examine elements such as inter-item correlations and check whether my measures are reliable as individual constructs. While there is no clear threshold for Cronbach's alpha scores, most researchers suggest that a value of 0.65 or 0.70 and above is acceptable (Girden, 2001), although some researchers accept smaller thresholds such as 0.60. I evaluated all my survey measures by using Cronbach's alpha scores, and report those with values greater than 0.75 as internally consistent measures. In addition, I conducted principal components analysis using SPSS to assess the validity of survey measures (i.e., uni-dimensionality of survey items).

Through the questionnaire, in addition to students' science attitudes, aspirations, etc., I also wanted to get as rich information as possible about Turkish minority students in terms of their specific ethnic background, their immigrant profiles, their parents, their family life, and their neighbourhood. As a result, in the questionnaire I included questions such as their specific ethnic background (mainland Turkish, Kurdish Turkish, Turkish Cypriot, other, see Chapter 2 for details of the constituents of the Turkish immigrant community in the UK), whether they were born in the UK, how long their parents have been living in the UK, educational levels of parents, their occupations, their English levels, spoken languages at home, their post codes, whether they live in a council house, rented or owned accommodation, as well as TV watching language.

For most questionnaire items in the survey, I used a five-point Likert scale (strongly agree, agree, neutral/neither, disagree, strongly disagree) with scores from 5 (strongly agree) to 1 (strongly disagree). To calculate the score for each child for each latent variable, corresponding item scores were averaged. For example, to calculate a student's general parental involvement score, I averaged her scores in the five corresponding items: a) "My parents/carers know how well I'm doing in school", b) "My parents/carers always attend parents' evenings at school", c) "My parents/carers know my schoolteachers very well", d) "My parents/carers help me doing my homework", e) "My parents/carers ask detailed questions about my lessons at school".

Also, there were some negatively worded questionnaire items in my survey such as ("I find science difficult"), for these I calculated the corresponding scores by subtracting them from 6. So, for example, if a student 'agrees' with the statement ("I find science difficult"), then his score for this item was calculated as 6 - 4 = 2.

The survey was designed so that students would be able to complete them in around 30 minutes. In deciding how to sequence the questions in the survey so students can most effectively complete it, I thought it would be important to consider initial warming up period for some students for the survey, and also potential getting bored or tired effect towards the end. Therefore, I decided to start with straightforward factual questions about the students and their family, followed by more complex questions such as on their science attitudes, parental involvement, activities etc., and finally completing the questionnaire with also more straightforward yes/no or three-point Likert scale (very interested/somewhat interested/not interested) questions.

In addition, in order to not bias students while completing the survey, instead of using more specific and detailed section titles such as "parental attitudes", "science aspirations", or "role model", I used more generic titles such as "your parents", "you in the future", or "people you know".

I piloted the questionnaire with Year 9 students at the Athenaeum School. Students completed it during the class time, and I was present throughout the questionnaire so that I was able to assist students and answer any questions they might have. Two minor issues were detected from piloting. Firstly, some students had difficulty with the meaning of two words with regards to their parents in the questionnaire: 'occupation' and 'postgraduate'. I explained this to students during the questionnaire as I was present in the classroom, also I replaced them with simpler word choices 'job' and 'masters' in the revised version. Secondly, students' completion of one question took much longer than I expected (i.e., perception of their ability to do general schoolwork based on Harter Scholastic Competence score, Harter, 1986). Because this was not an essential question in the survey (i.e., it was about general self-perception and had no science-related elements), I removed the question in the revised survey.

I included the pilot sample in my final survey data because no major issues were detected during the pilot, and the only difference was that students in the pilot spent slightly more time on one extra question.

4.4.2.2 Conducting the questionnaire

At the Athenaeum School, because almost all students were of Turkish origin and participated in the study, I conducted all questionnaires during the class time in their own classrooms. I was also present during these questionnaire sessions. In total, all 51 eligible students from year 7 to year 10 participated in the survey from the Athenaeum School.

At the ANS School, after identifying all Turkish minority students, school's Head of Science coordinated with class tutors to request students' participation. I conducted questionnaires to Turkish minority students by year group and class in multiple sessions. All questionnaires were conducted in the morning immediately after the registration in the school's café which was booked for us. Also, there were no other students in the café during these sessions, giving students suitable space to complete the questionnaires. I was also present during all the questionnaires at the ANS

School. In total, out of the 54 Turkish minority students identified in the ANS School in Year 7 and Year 10, 42 of them participated in the survey resulting in 78% survey participation rate at this school. The main issue for non-participating students was timing (lack of arranging a suitable time for students in some classes), and therefore there were no systematic differences between students who participated in the survey and those who did not.

In the schools in Istanbul, I also conducted all the questionnaires during class times. I was also present in the classroom during all the surveys. A total of 383 students participated in my surveys in the five schools in Istanbul.

4.4.2.3 Questionnaire analysis

After conducting surveys, for each student, I first manually entered all paper-based responses and scores for each variable item into Excel. I then calculated Variable scores by averaging corresponding item scores. After organising all the data in Excel, I then exported the data to SPSS. I analysed all surveys by using IBM SPSS Statistics version 22. Due to limited sample size, I mostly used univariate analyses to examine relationships between the variables. In my analyses, when distributions of the relevant variable scores were sufficiently close to a normal curve, I used one-way ANOVA. However, for measures with non-normal distribution, I used non-parametric Kruskal-Wallis test instead. I also conducted post-hoc Bonferroni tests for pairwise comparisons between specific groups, when I found significant group differences with the aforementioned tests.

4.4.3 Interviews

After getting approvals from the two schools, I then sought parents' and their children's participation in my interviews. I shared a short information booklet about my study and the consent forms along with my email address with the schools. These were prepared both in English and in Turkish (one language each side). The schools then shared/posted these documents to students' parents. While I got reasonable number of responses from parents at the Athenaeum School (who I subsequently called from their phone numbers provided), I received very few responses from the ANS School. This was partly because many parents were not commonly or frequently using internet/email communication. Therefore, I sent a second note to parents, but this time, I also included my telephone number so they could text or call me if they were interested in participating. The note read as follows:

> Dear parent, if you agree to be interviewed and/or allow your child to be interviewed, please simply send me a text at X or email X with your name, child's name and contact number. I will contact you for further details.

At this stage, I also received generous support from the school's Turkish students' liaison person, Mr Mahmud, who helped me reach out to parents and arrange interviews with them and their children.

4.4.3.1 Interview format and preparation

As part of my qualitative study, I conducted interviews with teachers, parents and students. The interviews were all semi-structured; that is, I had an initial set of themes to be explored and prepared an initial set of questions, but I was also flexible and open to the issues raised by my interviewees.

I started with teacher interviews to capture the views of teachers about students' attitudes and aspirations in science, and the various outside-school and parental factors affecting them. I also wanted to learn about teachers' specific experiences with Turkish immigrant students and their parents. Subsequently, I performed student interviews. Students were invited to participate to include students with varying levels of attitudes, capabilities and aspirations in science. Next, I conducted parent interviews. I tried to get a good understanding of various cultural contexts, parental attitudes, activities and actions, and how they may be influencing students' attitudes and aspirations in science. Also, in order to not bias parents or students about my research questions related to outside-school factors and explicitly about parents' role, I positioned my research and the interviews as a general study on students and science.

The themes I explored and the questions I asked during the interviews were also partly shaped and informed by the initial survey results in the UK. While with the survey, I collected data from more than 90 students, the information I obtained was naturally limited. Although I observe some initial patterns and interesting relationships from my survey data, in order to understand and explore specific mechanisms that result in these patterns, I needed a qualitative interview approach.

4.4.3.2 Conducting the interviews

The interviews were one-to-one and semi-structured. Each teacher, student or parent interview lasted about 30-45 minutes, and was audio-recorded with the permission of each teacher, student and their parents. I started student interviews with general questions such as their likes and dislikes in and out of school, and then I probed the factors that might affect their science attitudes and career aspirations, such as the availability of science-related resources at home and in their social network, role model visibility and their perceptions of their parents' attitudes to science and their education overall. Students were in general very attentive and talkative, and able to give vivid examples from their daily lives. After completing the interviews, they were transcribed verbatim using pseudonyms. I performed a total of 16 student interviews, of which 10 were from Athenaeum School and 7 were from the ANS School. Tables 4.2 and 4.3 provide a more detailed breakdown of student, parent and teacher interviews.

For the parent interviews, much the same approach was followed. Parent interviews were usually longer than student interviews (about 45-60 min) and they were carried out mostly at their homes. One advantage of conducting interviews at home was that parents were comfortable during the interviews, and seemed very open and genuine in their responses. Some parents' interviews were conducted at the interview room of the school, and with two parents, I conducted the interviews at a café they proposed. I only interviewed the mothers as fathers were reported to be busy at work. Also, when parents were asked for an interview, fathers proposed mothers to be interviewees. Interviews were undertaken in English or Turkish, depending on which the interviewee preferred. Overall, while getting the parents to participate in the interviews was a challenge, once they were in the study, then they seemed quite open, talkative and honest during the interviews. I performed a total of 11 parent interviews, of which 4 were from the Athenaeum School and 7 were from the ANS school.

Table 4.2 List of student and parent participants for individual interviews

School	Year	Gender	Pseudonym	Parent Interviewed	Parent Pseudonym
Athenaeum	7	M	Sinan	No	-
Athenaeum	7	F	Fulya	Yes	Gonca
Athenaeum	7	F	Mine	No	-
Athenaeum	7	M	Ekrem	No	-
Athenaeum	7	M	Zeki	Yes	Nihal
Athenaeum	10	F	Derya	Yes	Gonca
Athenaeum	10	M	Cem	No	-
Athenaeum	10	F	Irmak	Yes	Tanem
Athenaeum	10	M	Numan	Yes	Tulay
ANS	7	M	Ufuk	Yes	Gonul

ANS	7	M	N/A	Yes	Vesile
ANS	7	M	Berk	Yes	Behiye
ANS	7	F	Ayse	Yes	Bahar
ANS	7	F	Gozde	Yes	Isil
ANS	7	M	Omer	Yes	Umman
ANS	10	F	Nuray	Yes	Remziye

I also interviewed science teachers and other staff members at the two schools. I conducted a total of seven teacher / other staff interviews. Staff provided very useful and thoughtful answers to my questions.

Table 4.3 List of teacher and other staff participants for individual interviews

School	**Gender**	**Teacher / Other Staff Pseudonym**	**Role**
Athenaeum	M	Mr Harris	Science teacher
Athenaeum	F	Ms Kaya	Science teacher
ANS	M	Mr Ilbert	Science department head
ANS	M	Mr Lacey	Science teacher
ANS	M	Mr Fagan	Science teacher

ANS	M	Mr Mahmut	Turkish liaison
ANS	F	Ms Bailey	Career office manager

In total, the interviews took around 20 hours, of which around eight hours were with parents, 8.5 hours were with students, and 3.5 hours were with teachers / other staff.

4.4.3.3 Interview analysis

The interviews were analysed as follows. First, data were coded by focusing on emerging concepts and common themes in an iterative way (Miles & Huberman, 1994) with the constant comparative technique (Glaser & Strauss, 1967; Corbin & Strauss, 2008). In this technique, by comparing emerging indicators with previously identified ones within and across interviews, the goal is to "discern conceptual similarities, to refine the discriminative power of categories, and to discover patterns" (Tesch, 1990, p.96). Unlike grounded theory approaches, my goal with this analysis was not to generate new theory, but rather systematically to compare my codes and iteratively identify emerging themes which then formed the basis of my subsequent analysis, based on my theoretical framework.

Using the constant comparative technique, I first compared emerging concepts and corresponding codes within each interview, between student interviews, between student and family interviews, and between family interviews. After identifying key patterns and emerging themes related to outside-school factors and students' science participation in interviews, I then linked these themes with corresponding concepts of resources, conversion factors, capabilities and functionings in my theoretical framework. I include a copy of the coding framework in Table 4.1 below.

Table 4.4 Coding Framework

<u>Coding Category</u>	<u>Category Description (Sample Codes)</u>
Science interest and engagement	• Science is (not) fun • Science is useful • Science in daily life
Science at school	• School attainment • Interest to science lessons • Science as a favourite subject • Further study of science
Science at home	• Engaging with science at home (*documentary, movie, magazine*) • Using science at home • 'Space' at home as a constraint for science (*lack of a garden, small flat*) • Siblings and science
Science and parents	• Positive, pragmatic or negative interest in science • Parents' attitude to science
Science with parents	• Science conversations • Science as a hobby/activity • Science activity for school (homework, science project, contest) • Science in limited time • Science attitudes vs actions
Aspirations	• Higher education (*must go to university*) • Science aspirations • Girls: Early marriage • Education as an enabler for better life • Concerns for certain careers
Role models	• Limited role models in the family and relatives • Role models you get to know personally
Family socio-economics and education	• Parental education *(missed opportunities)* • Economic limitations (*money is never an issue*) • Family class and involvement
Life as an immigrant	• Life is hard (*working class, hard working parents)* • Family support • Different culture different practices

	• Interactions with 'others'
Ethnic minority identity	• Distinct/transnational identity *(neither Turkish nor British)* • Reproduction of culture *(Turks talk to Turks)*
Parents and education	• Involvement of parents in education (*verbal support*) • School as a black box • Expectations from education • Knowledge of the educational system
Turkey	• Role models 'in Turkey' • Visiting 'home' in the summers
Neighbourhood	• Neighbourhood as a source of role models (*not in this neighbourhood*) • Social networks • Peer effects • Closed circle
English literacy	• Parents' English as a deterrent to school involvement (*children as translators*) • Parents' English as a deterrent to involvement at home • Children's English literacy as an enabler for science

While I used NVivo for initial data organisation and management, in performing my analyses, I did not use software. This is because the data I collected were quite manageable in terms of size and complexity. Also, considering the criticisms related to the use of software in such qualitative work including the potential to creating distance, marginalising reflection and alienating the researcher from data (Kelle, 1995; Richard & Richard, 1991; Morison & Moir, 1998), and the difficulty of reconciling ICT with interpretive and creative stages of qualitative analysis (Roberts & Wilson, 2002), I preferred to carry out coding and analyses manually.

4.5 Ethical issues

While participants were not subject to risk of physical harm through taking part in this study, there were potential issues with regards to student participation and possible psychological concerns associated with it. For example, the focus of the study was Turkish students; therefore, Turkish students at the ANS School needed to be identified and contacted separately, which might made them feel anxious or singled out. In addition, contacting these students may present issues with regards to voluntarism. In order to address such potential concerns, I ensured that I presented my study to schools, parents and students in a positive and encouraging tone where a fellow Turk (i.e., me) needs help in her research study through their participation. In return, both parents' and students' reactions were very positive. It seems this attention by a Turkish researcher to their experiences and issues in relation to science and education was very welcome both by the parents and by the students. In fact, parents in particular were very interested and supportive of the study, with many parent interviews taking much longer than anticipated as a result of their lively conversations. I also ensured that the students did not feel obliged to take part in the study, both in my initial contacts with them and before the actual conduct of surveys and interviews.

For the student interviews, a purposive sampling method was used as I focused on the students in a pre-determined group. Voluntary informed consent was obtained from each participant prior to being interviewed. In advance of student interviews, their parents were informed and only when written parent consent was given, a date for a student interview was set. In addition, students' own consents were collected in oral form before starting interview sessions. Most student interviews were conducted in an available room in the school. Before each parent interview, the parent is asked about their preference for the interview location (e.g., their home, school office, a coffee shop) so that they could pick where they feel comfortable. This allowed to consider and minimise risks to their safety and confidentiality. All participants were also informed that they were free to withdraw from the study at any time without any reason. Students completed questionnaires at the school with my presence. No incentives and payments were offered for participation in the study.

The data were anonymised soon after collection. Anonymised participants' names were then transferred into an electronic form. The anonymised interview transcript data were stored on my personal computer while the interview tapes and participants' names were kept separately in a locked cabinet and on my computer; all electronic documents were password-protected.

For the data collection in Turkey, virtually all the procedures with regards to potential ethical issues were followed in the same way as in the UK. The only difference was that all data was collected in Turkish and translated into English by me.

A related consideration is the role of the researcher in the generation and interpretation of research data, which I discuss next. An important concern is reflexivity which refers to the researcher's construction of knowledge from the research process and factors that may influence planning, conducting and interpretation of research (Rose, 1997; Guillemin & Gullam, 2004). In addition, the biography, characteristics and perception of the researcher could also influence the ways in which participants interact with the researcher (May, 2003; O'Reilly, 2005).

The researcher in this thesis is a Turkish woman in her late twenties who grew up in Turkey and who has been living in the UK for less than ten years. The researcher's middle SES background, education level and being a mother could all play a role in both her construction of knowledge and participants' interactions with the researcher. Sharing a Turkish background and being an immigrant has helped the researcher in conducting this study because being an insider can help in obtaining access to research participants, asking more relevant questions and also having a more authentic understanding of the culture under study (Merriam et al., 2001). In this study, in addition to these advantages, the researcher's identity might have helped participants, especially parents and students, to be more open, comfortable and genuine during the interviews as their conversations were with a fellow Turkish immigrant. In addition, most of the parents preferred Turkish in the interviews which might have helped them express their feelings, perspectives and thoughts more fully. The researcher's identity, however, could also be a barrier, for example, for teachers during the interviews who might feel more reserved or 'careful' when discussing

Turkish immigrant students’ and their parents’ science attitudes with a Turkish researcher. In addition, the ‘insider identity’ of a researcher can also be weakness in a study and bias the findings if the researcher does not keep a distance but instead becomes too close to the participants to ask interesting and original questions (Merriam et al., 2001). Additionally, being a PhD candidate, the researcher’s high educational status could influence the way students and parents interacted with the researcher.

While I have been mindful of such potential issues throughout the study and took additional measures to address some of these concerns by, for example, expressing and discussing potential issues with regards to my shared ‘Turkish’ identity with teacher, student and parent participants, and by also collecting more quantifiable survey data, I should acknowledge that in this study participants’ shared information might have been influenced by my positioning towards them. In addition, I recognise that planning, collection and interpretation of data is not independent of a researcher’s relationship with the research, which is indeed a complex one in this study, influenced by my background and experiences both in Turkey and in the UK.

5 Chapter Five: Illustration of the theoretical framework: A case study of Turkish immigrant students in London

5.1 Introduction and case background

In this chapter, I illustrate the theoretical model developed in Chapter 3 with a case study. In particular, I explore the formation and expansion of science-related capabilities in three Turkish students studying in London, and the role of outside-school factors in influencing this process. By comparing and contrasting science-related capability development in three students, I empirically demonstrate how my model can be useful in enriching understanding of the role of outside-school factors in science education.

In light of my theoretical model, I illustrate the two-step science-related capability and functioning development of three Turkish-British students. All three students come from very similar socio-economic backgrounds and attend the same full time Turkish independent school, Athenaeum, in London. Of the three students, Zeki[3] (male) and Fulya (female) are in Year 7, and Derya (female) is in Year 10. Fulya and Derya are sisters. I selected students from Year 7 and Year 10 as most of the previous research suggests that aspiration and interest in science at the beginning of the secondary school is still high, but starts to decline afterwards (Archer et al., 2013). Using a combination of in-class observations, detailed questionnaires and student and parent interviews as outlined in Chapter 4, I was able to provide a rich picture of each student in terms of their formation of an initial set of science-related resources, conversion of these resources into science-related capabilities and, finally, conversion of these science-related capabilities into science-related functionings in the form of attitudes, aspirations and attainment.

During the in-class observations, I was able to observe whether each of Zeki, Fulya and Derya showed a genuine interest during the science lessons, and how attentive

[3] All names in this thesis, including students, parents and teachers are pseudonyms.

they were. Although the focus of my study is on outside-school factors, these in-class observations helped us prepare for subsequent surveys and interviews with the students, and also enabled us to verify some of their responses and comments.

In addition to in-class observations, I also made use of the students' questionnaire responses as well as interviews with the students and their parents. I analysed each of the three students' questionnaire responses, and compared them not only with the responses of the other two but also with the responses of the other students in their classes. I also conducted interviews with the three students and, separately, with their parents. Student interviews were carried out in an available room in the school.

5.2 Zeki, Fulya and Derya

I selected my three students for the following reasons: First of all, they all come from low socio-economic background immigrant parents, which potentially suggests a low level of initial resource set available for them. Secondly, Fulya and Derya are top-set students, and they seem to demonstrate a high level of science-related capability development, whereas Zeki is an upper middle set student in school, but with low levels of science-related capability development. Thirdly, although both Fulya and Derya show a high level of attainment and interest in science, Derya has high career aspirations in science whereas Fulya shows little interest in a science career (see Table 5.1 for an overview).

Because these students seem quite similar in terms of initial resources, but widely different in their science-related capabilities and functionings, they are ideal candidates for exploring the conversion process further with the lens of my theoretical framework. In addition, all students in this case study are from the same school, which suggests that their school factors are similar.

Table 5.1 The Cases of Zeki, Fulya, and Derya

Student	Parent	Initial Science-related Resource		Science-related Capability		Science-related Functioning
Zeki Year 7, boy	Nihal	Low	**Conversion Factors** **→** **(Stage 1)**	Low	**Conversion Factors** **→** **(Stage 2)**	Interest: Low Aspiration: Low Attainment: High
Fulya Year 7, girl	Gonca	Moderate		High		Interest: High Aspiration: Low Attainment: High
Derya Year 10, girl		Moderate		High		Interest: High Aspiration: High Attainment: High

5.3 The case of Zeki and his parents

The parents of Zeki have been living in England for eight years. They moved to England from a small village in Sakarya, Turkey. Zeki’s mother, Nihal, is a primary school graduate and his father is a high school graduate. Nihal works part time as a curtain tailor in her husband’s small curtain tailoring business and part time as a housewife. They live in a council flat in north London.

Zeki’s parents are supportive of his education; however, it appears that their support does not go beyond general and broad advice. His parents try to monitor Zeki’s school work and educational development, but this control appears to be somewhat distant. For example, when asked about any engagement with Zeki’s school work or projects in science, his mother Nihal indicated that she was never involved in his science-related school work or projects. Zeki and his parents seem not to share or engage much in terms of science-related learning, discussion of school or everyday topics or activities related to science. Nihal mentions language as a barrier on this as her English skills are quite poor, but Zeki always prefers English when it comes to school or science-related topics. Nihal mentioned an occasion at school in which she saw Zeki’s name on the board as being successful in science, and asked what this was about. Zeki struggled to explain it in Turkish, and without further efforts by Nihal, she never learned what Zeki’s achievement was. At this point, I asked Nihal what it was about, and she could barely say “it was something related to science lesson, and Zeki came first”. One point to emphasise is that this is a Turkish school, so most teachers are bilingual; therefore, information flow between parents who can only speak Turkish and the school should not be an issue. So, with some additional effort, Nihal could have learned from the teachers what Zeki’s real achievement was. Finally, regarding Zeki’s career aspirations and what his parents wish him to do in the future, his mother indicated that although she is not particularly interested in science, she “always admires doctors” and would like Zeki to become a doctor or a pilot, Zeki is not keen on either of these possibilities.

Although Zeki is among the high achieving students at school, science is not one of his favourite subjects. From the interview, and from his highly positive responses to survey questions about school science and science lessons, (e.g., “I would like to study more science in the future", "I do well in science", "I learn things quickly in my science lessons"), it is clear that Zeki does quite well in school science, and likes studying science at school. However, he does not have much interest in science beyond the classroom, saying "I do not usually use science". When Zeki was asked if he ever participated in a science project, he said "yeah", but "cannot remember what it was about, as it was years ago". Finally, Zeki does not have any aspirations in science or for a science-related career (he wants to be a businessman or a professional football player), nor does he have any science-related role models. Also, he is not involved in any science-related, outside-school activities.

5.4 The case of Fulya, Derya and their parents

The parents of Derya and Fulya have been living in England for 17 years. They moved to England from a small Turkish village in Greece. As with Zeki's parents, the mother, Gonca, is a primary school graduate, and the father is a high school graduate. Gonca is a housewife and the father operates a coffee shop, and they too live in a council flat in north London. Overall, both parents come from a low socio-economic background, which is quite typical for the Turkish immigrant community in England.

Derya's and Fulya's parents appear to be highly supportive of their daughters' education, but, unlike the parents of Zeki, they demonstrate high engagement with their education. Despite being only a primary school graduate herself, Gonca shows a genuine interest in the science-related topics that her daughters talk about. Both Fulya and Derya enjoy having conversations with their parents about new and interesting things that they learn in science, and their parents appear to enjoy this too. For example, when asked about details of science-related conversations with her daughters, Gonca recalls specific topics and gives examples, such as "the movement of atoms" and "the growth of animals". When Derya was asked about her favourite science topic in a separate interview, her response was "atoms and molecules". As is the case for Zeki's mother, Gonca cannot speak English. But both Derya and Fulya are confident in Turkish, and also feel comfortable translating science-related concepts for their mother from English to Turkish. As a result, they do have many science and school-related conversations with their parents. Their parents also appear quite dedicated in support of their daughters' science education. For example, when there were logistical problems in Derya's participation in an international science competition in the Netherlands due to last minute trip-organising issues with her school, her father took two days off work and drove her from England to the Netherlands just to make sure she did not miss the competition. Overall, both Fulya and Derya appear to be developing very high science-related capabilities.

5.4.1 The case of Fulya

Science is one of the subjects Fulya likes the most, along with English and mathematics. She likes all the subjects within science but physics is her favourite. She also remembers and explains the two science lessons this year she enjoyed the most, where they did experiments and made posters. Although she says she does not use science in her daily life much, she thinks she will use it more as she grows up. Fulya participated in a major science project in 2013 (the World Challenge project), in which she got a certificate, and she says she enjoyed the process and it helped her in terms of learning.

Fulya wants to be a lawyer, and this is not because of any role models or people she knows, but because she thinks "this job is best" for her. An interesting observation is that she says that previously she was thinking about being a doctor, but as her English has improved she now wants be a lawyer. Fulya considers her elder sister and her parents as role models, saying "if I work like them, whatever I do, I will be good at the end". She does not watch much TV, though she likes watching scientific and historical documentaries. Fulya also makes an interesting comment about visiting a science museum with school versus with her parents. She says she enjoyed and learned more when she visited with her parents as she says "with parents I am more relaxed, I take my time, and do not need to rush".

5.4.2 The case of Derya

Derya's two favourite subjects at school are science and mathematics. She likes a variety of topics in science, and her favourites are those related to atoms. She is not too excited about experiments, as she thinks some of them are repetitive, which makes them boring. She particularly likes numbers-related work in science, and "when numbers disappear, like in biology, then it makes science difficult for me, when there is lots of words and memorising". She also finds science very relevant, and she thinks she uses science quite often in her life.

Derya makes an important observation regarding the role of science in making sense of and understanding the world, and gives an example of how her science lessons "helped her understand how it is raining". As a top set student, she also participated in two international science-related contests: Genius Olympiad in the USA and Unesco Olympiad in the Netherlands. She finds being in competitions were very helpful in terms of learning, and says "she learns also a lot about other projects". When she is asked about whether she enjoyed preparing for and being at the competition, she replies "yes, I think the most important thing was I had a lot fun, it was really fun because I had loads of exciting activities". That is, she seems to enjoy the entire process of preparation and competition in science. She aspires to study medicine and become "either a physiotherapist or a heart surgeon or some kind of surgeon". Finally, Derya mentions the role of her family, saying "I have a lot of family support"; while they are not involved in her homework (except her mother's help with mathematics), they always support and encourage her, and the fact that her father took her to the Unesco Olympiad in the Netherlands and supported her there was very special to her.

5.5 Discussion of the three cases in the light of the theoretical model

The three main components of my model in which outside-school factors play a significant role, are: (i) a student's initial science-related resource set; (ii) conversion of the student's initial science-related resources to science-related capabilities; and finally (iii) conversion of science-related capabilities to science-related functionings (Figure 3.1).

5.5.1 Initial science-related resources

Considering both the case of Zeki and the cases of Fulya and Derya, I see that the two families are very similar in terms of their cultural backgrounds, ethnic factors and socio-economic status. So, at a first glance, one might think that both families are very similar in terms of the resources they provide to their children. However, when I take a more nuanced viewpoint based on Bourdieu, and take into account the role of parental attitudes to science and interactions within the family, I observe that the parents of Fulya and Derya provide a higher set of science-related initial resources than do the parents of Zeki. The difference in parents' overall attitudes to science is clear both from the interviews and from the students' responses to questionnaires. For example, both Fulya and Derya 'strongly agreed' to statements in the survey such as: 'my parents think science is interesting' or 'my parents would be happy if I become a scientist one day', whereas Zeki's response to these questions were only 'agree' and 'neutral' respectively. Overall, I propose that, despite very similar socio-economic status and parental, ethnic and sociological backgrounds, Zeki's parents and Fulya's and Derya's parents are not identical with respect to the initial science-related resources they provide to them. This is because of the difference in their attitudes to science.

Such different science attitudes shown by Zeki's parents when compared to Fulya and Derya's parents, combined with the conscious and unconscious practices that operate in these families (Bourdieu, 1992), result in each of the three children acquiring and forming a different science-related habitus. Because the characteristics of early socialisation in the home and family form the basis of all subsequent experiences (Bourdieu, 1992), I would expect habitus differences to have a lasting impact on Zeki, and Fulya and Derya. While Fulya and Derya have a good 'feel for the game' for science, Zeki seems not to develop such a feel because even a simple conversation in science is not possible in his family with language acting as a further barrier. Without the basic English language skills to enable his parents to interact with Zeki, whose science conception and vocabulary is almost entirely in English, and with a lack of interest and persistence in pursuing such conversations, his family does not help Zeki form a real ‘feel’ for science. In fact, for Zeki, science seems to ‘disappear’ when he is at home.

One benefit of my model is to highlight these nuances on the role of families in providing initial resources. Using only common survey items on parental education and occupations or ascertaining students’ family or ethnic backgrounds would give us only part of the whole picture regarding the role of parents in providing initial science-related resources and habitus.

5.5.2 Conversion from science-related capital to science-related capabilities

I suggest that certain parental actions and practices outside the school act as conversion factors in converting students’ science-related resources into science-related capabilities. Indeed, in the case of Zeki, compared to Fulya and Derya, I observe major differences in the development of science capabilities. From the interviews, class observations and survey responses, Zeki appears to have low/moderate science capability. Although he is good at school science, he does not show any interest in science outside the school. His responses to the survey questions designed to get a sense of students’ science-related capabilities (e.g., ‘When I learn an interesting science topic, I can learn much more about it at home’, and ‘If I want, I can undertake an experiment during a science class to a high standard’) were all neutral. Zeki’s parents’ encouragement and support in science is quite limited and articulated in very general terms. They also do not do science-related activities with Zeki (in the survey Zeki’s answers were ‘no’ to all eight questions on science-related activities with parents).

On the other hand, both Fulya and Derya appear to have very high science capabilities. They are both very comfortable and confident in science-related conversations, they show genuine interest in science and science-related topics inside and outside the classroom, and they both scored very highly on survey questions for science-related capabilities. In contrast to Zeki’s parents, the parents of Fulya and

Derya are very much engaged in their support and involvement in science. They have many lively conversations with their children related to science, are very committed and proactive in their support of their science activities and very genuine in their interest in science (they seemed to enjoy and remember many science-related conversations during the interview). In addition, survey responses of both Fulya and Derya indicate that their parents do many science-related activities together with them (their scores in this section are much higher than those of their class averages). Furthermore, in the interview, Fulya's and Derya's mother, Gonca, shared with us several other activities and actions that happen at home. For example, the parents buy books (science and others) for their daughters, and take them to science museums as a family.

An important point to note is that Zeki, Fulya and Derya attend the same Turkish independent school, so they have the same school 'field' (Reay et al., 2009) to assist them in developing science capabilities. In addition, my interviews and observations indicate that with its emphasis on STEM subjects, innovative science curriculum and encouragement for science projects and Olympiads, the school provides a highly conducive field for students to develop science capabilities. However, this same field does not necessarily provide the same level of conversion for Zeki, Fulya and Derya from initial science-related capital to science-related capabilities. Fulya and Derya experience very similar and conducive fields for science both at home and at school with high expectations and high engagement. As a result, as Bourdieu and Wacquant (1992) suggest, this consistency between fields makes them feel like "fish in water" (p.127), whereby they can take full advantage of their school science. Zeki, on the other hand, encounters a very different science field at school compared to what he experiences at home. This incongruity constrains Zeki's conversion and science-related capability development as he feels "the weight of the water" (p.127) at school and, despite being provided with many opportunities at school to help develop science capabilities, he makes very limited use of them.

To sum up, I observe a significant difference between Zeki compared to Fulya and Derya in science-related capabilities, and I argue that this is primarily because of the major differences in their conversion factors (e.g., parental actions) and in their fields in which conversion takes place.

5.5.3 Conversion from science-related capabilities to science-related functioning

Building on Sen's distinction between capability and functioning, I highlighted the difference between science-related functionings (outcomes achieved by individuals) and science-related capabilities (ability to achieve desired functionings). As outlined in Figure 3.1, two different sets of conversion factors play a role in their development. The first set of conversion factors play a role in converting science-related initial resources into science-related capabilities as outlined in the previous section. A second set of conversion factors play a role in converting science-related capabilities to science-related functionings. I argue that what matters is for students to develop science-related capabilities, even if these do not translate into science-related functionings. I suggest that there is nothing inappropriate if a student does to not choose a science career so long as she is well-informed about science and has developed science-related capabilities, but with her own free will decides to pursue something else.

While both Fulya and Derya demonstrate a high level of science-related capabilities as outlined above, Derya is very interested in science careers and wants to become a doctor, whereas Fulya has her passion in law, and wants to become a lawyer. Both Derya and Fulya do very well in science lessons, and enjoy doing science-related activities outside the school. They certainly both feel themselves capable of pursuing science careers. But with their own reflections, freedom and choice, they want, at least at this stage of their education, to pursue different careers. My observation and conclusion is very much in line with Archer et al. (2014)'s work on adolescent boys' science aspirations which observes that some boys (i.e., "behaving/achieving" ones) do not aspire to careers in science despite having very good identification and attainment in science.

However, the case of Zeki is different. I do not observe any significant science-related functionings in Zeki both in terms of attitudes or aspirations. His attainment in science is quite high, but because of the lack of conversion factors (at both the first and second stage), he does not show much science-related capability or functioning development.

5.6 Discussion

The case study demonstrates and provides evidence for three main ideas suggested in the two-stage model introduced in Chapter 3. Specifically, the model's first main idea is that each student is provided with an initial set of science-related resources that are influenced by parental socio-economic status as well as by cultural and ethnic factors and parental attitudes to science. In my cases, Fulya and Derya have greater initial science-related resources than Zeki. The second main idea in the model is the conversion of initial resources to science-related capabilities. While I observe significant conversion leading to a very high level of science-related capability development in Fulya and Derya, the lack of such conversion factors leads Zeki to develop much lower levels of capability development. This low level of science-related capability combined with no major conversion factors in the second stage (from capability to functioning) results in Zeki showing neither positive attitudes towards nor aspirations for science. This second stage conversion from science-related capability to science-related functioning is the third main idea in the model. The difference in the career aspirations of Fulya and Derya reveals the distinction between capabilities and functionings. While Derya is very much interested in a science-career, Fulya is not. Fulya's lack of interest in science-related careers may be a lack of some conversion factors in the second stage (e.g., not seeing the appeal in such a career).

These cases also show how my model can be useful for gaining deeper insights into the role of outside-school factors in science education. For example, without the two-stage model, if one looks at the case of Fulya, one may only see the input and output, that is, an immigrant student from a low socio-economic status background and low aspirations in science. One might then conclude that this is another example of low socio-economic status leading to low aspiration. In fact, Fulya has very well developed science capabilities; outside-school factors, particularly parental actions, played a significant role in developing and enhancing these capabilities, and her current decision not to pursue a science-related career is her own choice.

6 Chapter Six: Qualitative (interview) findings

6.1 Introduction

Building on the theoretical model developed in Chapter 3 and using parental (n=11), student (n=16) and teacher and staff (n=7) interviews, this chapter explores in detail the model of science-related capability and functioning development. In the following sections, I will first present results on initial science-related resources, and then discuss the first set of conversion factors that lead to development of science capabilities. Finally, I will present results regarding development of science functionings and associated conversion factors,

Interviews were conducted in two schools in London (one independent Turkish school and one maintained school with a large Turkish student population) as outlined in Chapter 4. As discussed in Chapter 4, I analysed the interview transcripts in an iterative way in light of the theoretical model by using a constant comparative technique (Glaser & Strauss, 1967; Corbin & Strauss, 2008). My goal was to systematically compare my codes and iteratively identify emerging themes to form the basis of my subsequent analysis, based on my theoretical framework. I compared emerging indicators with previously identified ones within and across interviews (i.e., between student interviews, between student and family interviews, between family interviews, and between student, family and teacher interviews). After identifying key patterns and emerging themes related to outside-school factors and students' science participation in interviews, I then linked these themes with corresponding concepts of initial science-related resources, science capabilities, functionings and respective conversion factors.

Inter-observer (inter-rater) reliability is not applicable and therefore not calculated for these analyses as there is only one person, myself, to conduct and analyse the interviews. Inter-observer reliability refers to the degree to which different raters give consistent estimates of the same behaviour. The assessment of inter-rater reliability is often necessary for research designs where data are collected through ratings provided by multiple trained or untrained coders (Hallgren, 2012). I have not utilized any other raters or data collectors for my data collection as being the person who designed the entire research study, and being multilingual to interview both Turkish as well as English speakers in my sample, I tried to maximise the consistency in data collection with a single data collector.

6.2 Initial science-related resources

6.2.1 Cultural and ethnic factors: The role of being immigrant

All the students who participated in the interviews are Turkish minorities whose parents migrated to the UK from Turkey. However, it is important to note that there some parents migrated in the past decade and therefore their children were born in Turkey but raised in the UK, other parents migrated much earlier when they were themselves a small child or a teenager or a young adult. Nevertheless, being an immigrant is a key characteristic that defines these families. Almost all of the parents call Turkey 'home', primarily watch Turkish television channels, and have most of their social interactions within the Turkish community in London. These parents also feel quite profoundly about their ethnic minority position by referring to themselves as 'us' and the dominant British population as 'them'. Most of the parents live in an area with a high population from the Turkish community. It is common to take children to Turkish weekend schools, and participate in activities in Turkish cultural centres and Turkish mosques. A large majority of the parents' social sphere consists of relatives and neighbours from a Turkish background.

Home culture is a key defining element in these individuals' daily lives, which is also reproduced by frequent interactions with family members, relatives and friends both in Turkey and in the UK. The nature of the interactions, however, takes quite distinct forms depending on the physical location. While interactions with relatives or friends in Turkey are limited to phone, email or Skype conversations, much deeper interactions take place with fellow immigrant relatives and friends who are in the UK. These are mostly facilitated by mothers or students (classmates) and take the form of regular visits to each other over tea and food, weekend activities such as picnics, among others.

Another observation about immigrant families is that they seem to generate a distinct culture of their own, which is different from both the present-day culture in Turkey and typical British culture today. Practices associated with this culture are in some ways surprisingly conservative compared to present-day practices of Turkish families in Turkey. These may include past practices that existed in Turkey at the time when these families moved to Turkey but which no longer exist. This is widespread phenomenon for immigrants from any country. For instance, Foner (1994) mentioned that immigrants (in United States) continue to draw on pre-migration family experiences, norms and cultural frameworks as they carve out new lives. Such 'living in the past' may be a result of the limited and surface level interactions with friends and family in Turkey which limits cultural and social exchange between immigrant families in the UK and their friends in Turkey. It may also be a desire for immigrant families to preserve what is familiar to them. I vividly observed this during my parent interviews as most of the parent interviews were conducted at parents' homes. A few of the parents' houses I visited reminded me the houses (with the decor, furnishings and goods) I saw and experienced when I was a child in Turkey 20-25 years ago, rather than being reflective of a present-day Turkish home in Turkey (of a similar socio- economic status). For example, during my visits, there were several occasions when I saw wall carpets with deer, which was very popular in Turkey during the 1980s, but which are no longer common in Turkish homes these days.

Figure 6.1 A typical wall carpet popular in Turkey in the 1980s

Most of the families visit Turkey once a year during the summer holidays. Although almost all students report enjoying the time they spend in Turkey during these holidays, they also say they quickly miss London as they feel they belong more here. Some students mentioned the difficulties they encountered back "home". These include adjusting to daily life in Turkey, communication issues and language difficulties (with their imperfect Turkish skills) and, more importantly, being stigmatised as gurbetci" (a Turkish expat living abroad). Irmak (Year 10,), speaking in English, highlighted language issues and difficulties in adjusting to life in Turkey during summer holidays:

> I love Turkey. In Turkey it is like a different atmosphere, families are very big, everyone comes together. My Turkish is very bad, I can speak but it is very different. And I don't really enjoy talking in Turkish. My English is stronger. In Turkey everyone speaks Turkish, I feel like it is difficult for me. I usually love telling my mom something and then she would translate for me, but still difficult. Obviously if I settle there, I can change that, I can get better. But I am so used to the system here.

Mine (Year 7) also describes her days in Turkey as follows:

> I feel happy but sometimes a bit out of place, because you see I was always in England, I was born here and I speak in English so when I go there I feel like I am being left out of the culture.

Zeki (Year 7) who moved to London when he was 3 years old, on the other hand, reflected his feelings about being in Turkey as:

> I feel much better in Turkey. Relatives, family, I feel comfortable. I don't like this place, Turkey is better. Everything is better there because I was born there.

My analysis of the interviews suggests that being immigrant appears to affect initial science-related resources provided to students in three major ways. Firstly, most immigrant families are working class with very limited financial and social resources in the UK. As a result, they need to work hard for long hours resulting in limited time for family and for non-work activities. In my interview sample, fathers' occupations include working in kabab shops, cafes or restaurants, as hairdressers and minicab drivers, among others. While most of the mothers' are housewives, paid occupations include being a tailor or sewing. Such occupations by nature are time consuming, therefore leaving little time for other things.

One mother, Umman, for example said:

> Ahmet is a good hard working father, and he wants to spend time with the children … to talk about classes and school … but it is just not possible. He closes the off licence shop at 1am and again opens it at 6am. So, he rarely sees the children during the week.

Therefore, for some parents, even if they want to interact with their children and to get involved in their studies and learning, structural limitations are often so great that this is not feasible.

Secondly, as immigrant parents whose family and relatives networks are primarily based in Turkey, they are not able to get enough family support while their children are growing. For example, they don't have grandparents who can take care of some duties such as dropping off and picking up the children. This limited social network hinders some of the resources that are readily available to non-immigrant students.

Thirdly, immigrant parents' limited English language ability is an important deterrent for providing initial resources to students. With limited language skills, parents have major difficulties in connecting and communicating in an English-dominated culture. This not only limits their involvement at school, but also acts as a broader deterrent leading to limited understanding of the British educational system and unfamiliarity with the opportunities and potential obstacles that are present in the system.

Mr Fagan, a Science Teacher at the ANS School, points out these three dynamics:

> When you look at parents of immigrant students, they are dominantly from working class, lack of jobs, lack of opportunities, it is why they moved here in the first place. Many of these [immigrant] students are being used by their parents as translators, and they are more focused on what the children can do

for them than, from my perception, what the student can get out from education. Some take them out of school to do work, or some expect these kids to work for them after school or during the weekend in this community.

Similarly, Mr Ilbert observes:

> I think there is an issue that a lot of those parents weren't born in this country and English is maybe their second language, they may not be familiar with the education system here. So, I think those barriers exist for a lot of parents coming from that group of students. Therefore, there doesn't exist the expectation that what they will become. I am not sure. They don't know much about the system or university education in the United Kingdom, what opportunities are available, so there is not that expectation for those students.

The observations and findings in this section are in line with previous research on immigrants which highlight the effects of being immigrant on identity as well as on cultural and daily practices (Bhabha, 1994; Hall, 1996; Schiller, Çaglar & Guldbrandsen, 2006). Indeed, everyday lives of Turkish families in the UK are constant negotiations of both transnational ties and local attachments (Ehrkamp, 2005) as they construct a unique identity in their daily practices. These parents could also feel or experience prejudice, discrimination or judgement by the educational system (Roth & Calabrese-Barton, 2004; Carlone, 2003; Rahm & Ash, 2008) which may compound the disadvantages already experienced by ethnic-minority and immigrant individuals. Even those middle-class Turkish immigrant parents who can deploy wider resources and strategies for their children than Turkish parents with lower socio-economic status may still be subject to racial inequalities that can limit the extent of their potential class advantage (Archer, 2010).

In addition, as discussed before, most Turkish immigrant parents' involvement with their children appears to be affected by limited time availability, which has been suggested as a critical predictor of parental involvement (Muller, 1995). One implication of being an immigrant is the composition of the family where most relatives, including grandparents, live in Turkey, and are therefore not able to provide additional resources for assistance. In fact, in multigenerational households where grandparents can provide support such as child-care, parents have been suggested to have greater opportunities for involvement (Bengtson, 2001). Finally, my interview findings suggested that parents' limited English language ability is a critical deterrent in providing initial resources to students, confirming previous research which found immigrant parents' language skills to be an important barrier for parental participation (Turney & Kao, 2009).

6.2.2 Family socio-economic status

Most of the interviewees in my study come from low to moderate socio-economic backgrounds. Most of them live in council houses, graduated from primary school or left school during/after secondary school. They are mostly employed in working-class occupations, and half of the mothers in my sample are housewives.

Family socio-economic status is widely reported in the literature as an important dimension that significantly affects one's aspiration, attitude and attainment. However, an important theme that emerged from the interview analysis is that despite coming from low to moderate socio-economic backgrounds, parents and students often say that they do not see major obstacles associated with parents' educational and occupational status or financial/economic status in reaching their educational goals as long as students work hard enough. Parents indicate that for the success of their children "money is never a problem" and students mostly have a similar perspective. Only after I probed them about more nuanced SES-related mechanisms that may act as obstacles such as role model invisibility, finding job experience, getting advice from peers, etc. did they mention these as potential obstacles. Overall, this is perhaps a surprising finding in that despite being very much aware of their low and moderate socio-economic status, parents and students do not see this as a major obstacle for children's educational progress. Although parents do acknowledge the role of more nuanced structural elements associated with the socio-economic status (access to role models, peers, social networks etc), they think that socio-economic status has little or no direct impact on educational outcomes. One parent who lives in a council estate, Behiye says: "We have no economic limitation whatsoever"; another parent mentions: "She (daughter) is very smart, she can do if she wants do … And she does not have any economic obstacles

…Well, as a matter of fact, I think economics is not an issue for anyone these days for studying".

The Turkish liaison person at ANS School, Mr Mahmut, shares this view, saying: "I can give you many examples with Turkish students with very limited SES doing very well at school and careers, and vice versa". He continues:

> Most Turkish students in my school do have very low SES, although there are exceptions. But I don't think SES is directly correlated.
>
> Tuba: Do you mean SES is not related to aspirations or attitudes in science?
>
> Mr Mahmut: There is of course some difference between parents of a top set year 9 girl whose father and mother have professional jobs here compared to another student whose parents come to London after leaving their small farm work in a village in Kayseri (a town in central Anatolia) … Also, if family is resourceful, cultural, economic, educational, students don't have much integration problems. But, overall, I think it very much depends on the individual student, not necessarily SES. For example, we have two students with very similarly low SES. One of them wants to be a minicab driver, despite being a high performing student, and the other wants to be pilot. The first one has got a very close relationship/connection with his father who is a minicab driver and (he simply wants to be like him). The second student, whose father and mother are separated, wants to be a pilot and he is serious about it, he now goes to a course for it, and he is highly ambitious about it.

Actually, when the second student's mother, Bahar, was interviewed and asked whether her son enjoys the pilot course, she said: "Yes, so much so that the one thing he loves most is football, but now he skips football and goes to this course".

Of course, an alternative explanation may be that these parents are not fully aware of the potential opportunities that are linked to financial resources. These may include getting private tutoring, extra lessons or sending their children to private schools. Similarly, they may be only considering the direct consequences of economic status, and thinking that many services associated with their children's education are indeed free (public schools, museum visits, libraries, etc). That is, these parents may not be aware of the potential exchange value (Skeggs, 2004) associated with economic, cultural or social capital and how it can provide additional advantage to those who possess such capital.

Overall, most Turkish parents saw socio-economic status as a minor, or non-existent, obstacle in their children's education in general and in their science participation and outcomes in particular. This suggests that, from the parents' point of view, while socio-economic status can act as an initial resource provider, its effect on students' development of science capabilities is perceived to be limited.

A large body of literature has reported strong associations between socio-economic status and academic achievement (see, for example Gorard & See, 2009 for a review for science). It is clear that science participation and achievement is patterned by social class and socio-economic background (e.g., Calabrese Barton, 1998; Smith & Gorard, 2011; Strand, 2007; 2011; Archer, Dewitt & Wong, 2013). On the other hand, in an early meta-analytic study of more than 200 papers, White (1982) reported that SES is only weakly correlated with performance. Moreover, he found that family characteristics such as 'home atmosphere', which is sometimes incorrectly referred to as SES, had a much stronger association (4 to 11 times higher) with academic achievement than did traditional SES measures such as family income, occupation or education. In addition to this lack of significance in the relationship between SES and academic achievement, similar results were reported on the relationship between SES and students' science attitudes, in particular. Multiple studies have shown little or no significant association between students' science attitudes or science achievement and various dimensions of SES such as family income or family education (Fleming & Malone, 1983; Borger & Walberg, 1983; Van Voorhis, 2003).

My interviews with Turkish immigrant parents appear to echo the aforementioned findings in the literature in that Turkish parents' see their socio-economic status as a minor factor in influencing their children's science participation and achievement. While I do not disregard the vast literature linking socio-economic status and science participation, I suggest that family socio-economic status only partly explain the initial science-related resource set of students and I would argue that the main mechanism by which SES affects science participation and outcomes is one that operates indirectly through other conversion factors and at other stages, such as during capability development.

6.2.3 Parental science-attitude as an initial resource

From the interviews, parental science attitude emerges as an important initial resource for students. As an initial resource, I consider inherent attitudes of parents that are not necessarily a result of conscious decisions or choices, but rather how parents feel and think about science in general. Three primary patterns emerge with regards to parents' science attitude; I classify them into three groups: *positive, pragmatic* and *non-positive.*

The first group of parents appear to have a genuine interest in science independent of their children, their own educational background or occupation. Although a small group, when compared to others, these parents have genuine curiosity and interest in nature and science-related matters. It is not just a statement of interest, but an actual and genuine involvement, including spending time outdoors and exploring nature, interest and knowledge on plants, animals, etc. They are knowledgeable or interested in science-related news, watch TV programmes on science and they do these not because it is a good or right thing to do (for them and for their children) but because they enjoy doing so. These are the kinds of parents who feel excited and passionate about talking and learning science-related things, who prefer watching Planet Earth over other TV shows. A good representative of this group is Isil:

> I am just a middle school graduate, but I always loved nature and science things. It has always been this way, even when I was a child in a little village in Turkey. Here (London) it is very green, many beautiful parks, many different plants to see, to learn, to enjoy. I know a lot about soil. Also, on TV there are shows like they make medicine from plants and flowers, I don't miss such programmes, I wish we had a large house and a garden to grow many flowers and plants, instead of this small (council) flat.

Similarly, Tulay (Numan's mum) says:

> I pay a lot of attention on health-related news. Like when they find a new treatment for cancer … Kids get bored quickly watching science programmes, but I love watching, things like Planet Earth. Maybe also because my English is not good, I prefer watching these instead of other TV shows or movies.

> When I was a child I was dreaming about being a nurse and I have always been very interested in health-related things. I have got a book about family health; it is almost an antique by now. I have been looking up that book since my childhood. A few years ago my husband brought two books about illnesses and their symptoms to home. Since then, Numan was constantly looking up those books and telling us about his reading like these sort of symptoms appears when one get this illness and so.

Such natural and genuine interest of parents in science provides a very strong initial science-related resource set for the children. Even if they may not share the same level of interest, such as Tulay's son Numan, children inevitably develop early awareness and appreciation of science. As mentioned earlier, however, such parents are in a minority.

A second group which represents a larger portion of parents is what I call *pragmatic* parents. These parents do not necessarily have much interest in science, but nevertheless their attitude is quite positive, they think science is essential for life and for being successful in school. While some of these parents are well aware of the specific benefits of doing well in science, a large majority of them take it to heart; they know and admit science is important, but they are not able to articulate how or why. A teacher at Athenaeum School illustrates such parental attitude:

> Last year, a parent attending a parents meeting, and she had just one question: 'What does my daughter need to become a doctor? Which classes she needs to take?'. Oh, OK. So, we do have parents with a very strong support, and do understand the importance of science especially for those kinds of careers like medicine. I think generally speaking parents are very, very supportive of science.

A third group of parents has non-positive attitudes to science. These include those who are indifferent (not providing any positive or negative views) and those who express genuine dislike or disinterest about science. They think it is hard and boring, or mostly not useful. Gonul, for example, is quite open about her view:

> To be honest, I personally find science boring, since my school years. My grades in science lessons were horrible. Ufuk (her son) is similar, he just doesn't like science, maybe it is genetic.

When I asked Berk about his parents, he said:

> My mum and dad don't like and understand science. They had a different knowledge. They don't really understand most science matters.

Tanem, who is Irmak's mum also revealed her dislike of science and how it might have influenced her child:

> To be honest, throughout my childhood in secondary and high school, I was awful in science. I hated it. Maybe we now influenced Irmak too.

Overall, these three groups (*genuinely positive*, *pragmatic* and *non-positive*) provide quite different sets of initial science-related resources to their children. While such differential sets of resources certainly play a role in influencing students' science participation and aspirations, as I argued in the theoretical model, this only partially reflects the entire picture. Indeed, there were multiple examples in my interview sample where students demonstrate high science participation and outcomes despite being endowed with low initial science-related resources (e.g., non-positive parental attitude, a low SES). Similarly, there were several examples where the student demonstrates lack of interest and aspirations in science, despite having genuinely interested parents in science or despite having a very conducive cultural environment. I discuss this further in Sections 6.3 and 6.4.

6.2.4 Beyond structural limitations: A capability perspective

Despite the importance of structural characteristics, initial resources may only partly drive and form students' science aspirations, attitudes and attainment. That is, as long as they have an effective conversion mechanism, students can still develop science capabilities despite having limited initial resources. Based on my theoretical model, I argue that, in developing science capabilities and functionings, conversion factors and agency can play a significant role beyond the initial resource available and structural limitations. In Section 6.3, I discuss primary elements of science capability development and associated conversion factors that emerge from the interviews.

6.3. Developing science capabilities

6.3.1. Parental involvement (general)

Interview analyses reveal that parental involvement in general can be a key enabler or obstruction of science capability development in immigrant children. As immigrant parents, parental involvement in their children's education and schooling may not be straightforward or as easy as for a native British parent, but still there are very good and not so good examples from Turkish parents. Science teachers particularly highlight the role of parental involvement and support. There also appears to be a significant difference between the parents in the two schools: the independent Athenaeum School, where parents seem to be more involved and the maintained ANS School, where the involvement is much less.

A science teacher at ANS, Mr Ilbert points to an important limitation in Turkish immigrant parents' involvement with their children's education, namely knowing what is needed to be done, but not knowing how to do it:

> Parents who are more involved their child's education are more likely to get a tutor, more likely help homework and provide that support. And those students make more progress. And the students that are lacking from that support are less likely to be making progress. I think lots of our Turkish

> minority pupils fall into the second category where parents want their children do well, but maybe don't know how to go about how to make sure that they do well.

Mr Fagan, a science teacher at ANS School, provided detailed comments on the limited parental involvement and support for Turkish students at ANS:

> I would say that parents always want their kids to do well but they have to show it as well in the support that they give to the students, you know. And I don't think the students actually see that coming from particularly parents we have. They don't feel that much of support from their parents … I think it is basically verbal support. "Oh! Go and do your homework", but they do not follow it through. When I phone home and say "your child hasn't done this yet" they say "oh so sorry, I will make them do the homework" but they just tell them and it is usually the mothers that we speak to, and the mothers, Turkish mothers, tend to have a very loving kind of relationship with the child and it will be things like "Oh if it is so difficult, don't worry about it. Just tell the teacher that you can't do it" rather than "Well, you can go to library, and look it up and work it out. Or even I can help you, or you can go and ask the teacher' but no they say "Sweety, it is OK, no problem" you know, and that sort of thing. They support them in that way.

Although he acknowledges potential factors like language which may make involvement harder, he also says:

> We offer lots of help, information being written in different languages including Turkish, and we have got a Turkish helper here for them to assist parents getting contact with and so on. Often their complaints are not really about the work or how the students are doing, but it is generally about: "Oh! this teacher is picking up my child and you know this sort of things just everyday ..." but it is never about 'I am going to contact the school and ask them how well he is doing in certain subject and what sort of things that I could do to help him'. We have meetings for parents to come and discuss children's work and so on. When we offer this only a handful of parents actually are turning up.

In addition, it seems like parental involvement of Turkish minority students in the ANS have been lower with compared to other groups, and there are gendered differences:

> Mr Ilbert (ANS Head of Science): … considering whole school but overall TKC [Turkish minority] pupils make progress not in line with the other groups, I think it is getting better, especially among the girls and TKC girls make better progress than the TKC boys, I think.
>
> Tuba: Do you see any reason behind it?
>
> Mr Ilbert: I think this is an element of expectation from home, support from home. So, for instance, lots of our white middle-class kids…their parents of these kids are very much involved in their education and supportive and probably they help their kids in their homework. And I think especially with the TKC pupils that's not very much the case. I am doing my best to try to involve the parents, and getting them with the help, presence of Mr Mahmut in terms of as a liaison between us and them. I think there are lots of work we need to do still to improve it.

Mr Fagan, also recognises structural limitations, but again he thinks individuals' agency could make a big difference. Interestingly, and in line with the previous observations on the role of socio-economic status, he also thinks that SES is not so much of a problem once the family is settled here:

> It is a very difficult problem to try to work out because it depends on individual families as well. Even if they are from poorer background but if they are settled in this country, they may have time to help their child and do the homework together and they can show some interest in their work. And I think that's what they basically should do. They shouldn't say "Oh this is in English, I don't know". Just show some interest, let the child teach you something, and then by teaching you, they are learning themselves too. You know, that sort of thing rather than saying "Oh! Go on, that's your work, get on with it", that sort of thing. Showing interest would make a huge difference. Because the child would know that their parents are with them. If

> they do the homework together, then parents would say: “Oh, you had that homework, what did you get from it?”.

These observations are in line with the literature which highlights the strong connections between parental involvement and student participation and educational outcomes (Baker & Stevenson, 1986; Crosnoe, 2001; Desimone, 1999). Indeed, parents’ greater involvement can help develop more positive school attitudes and participation, and increase achievement (Epstein, 1987; Fehrmann, Keith & Reimers, 1987; Turney & Kao, 2009). As Mr Fagan repeatedly pointed out in my interviews, such involvement can be particularly valuable and beneficial to children of immigrant parents (Kao, 2004; Kim, 2002) who typically experience greater barriers for involvement (Carreon, Drake & Barton, 2005; Turney & Kato, 2009).

My interview findings also pointed to different dimensions of involvement including involvement at home (e.g., with homework) and involvement at school. Such multidimensionality of parental involvement has been recognized previously (Domina, 2005; Sui-Chi & Willms, 1996). In line with my theoretical model and my interview observations suggesting a limited role of SES, Sui-Chi and Willms (1996, p.137) found “little support for the conjecture that parents with low socioeconomic status are less involved in their children's schooling than are parents with higher socioeconomic status”. What they did find was that, particularly at home, ethnic-minority parents were more involved than were white parents. This, of course, should not make us neglect the many challenges experienced by Turkish immigrant parents mentioned earlier around time availability, language, lack of extended family, among others. Indeed, social class resources and corresponding limitations, and immigration experience interact in complex ways in Turkish parents’ involvement with their children’s education.

6.3.2. Parental aspirations as a conversion factor

Parental aspirations appear to have significant influence on students. A finding from my interviews is that, contrary to my initial expectation that I would see two groups – some parents with high aspirations and some with low aspirations – a third group existed who have what I call ‘negative aspirations’. Some parents may actually be demonstrating a negative influence on their children with perhaps a negative perspective on certain high aspirations. They find such aspirations to be unrealistic, infeasible, or unimaginable, and communicate this to their child(ren). For example, a parent, Remziye says:

> Nuray always asks me, mum do you see me as a doctor or as a nurse?
>
> Tuba: So, what do you say?
>
> Remziye: I look at it whether it makes sense, whether it is feasible?
>
> Tuba: So, how about being a doctor or a nurse for Nuray?
>
> Remziye: Hard, very hard. You spend all those long years, it is very difficult. You deal with all kinds of people. And then if you are a clinical doctor, prescribe a wrong pill … it is very risky. If you ask me, I would prefer to be a fashion design/sewing teacher. I tell her, become a teacher, it is a very prevalent job. If she can’t do it here, she can do it in Turkey.

Another parent shows a similarly negative attitude by highlighting risks associated with a career aspiration; Nihal comments about her son:

> He wants to become a pilot. It’s very risky … lots of hardship … people’s lives are dependent on you.

Another parent is even more discouraging:

> My son tells sometimes he wants to become a science professor. (Laughing) I don’t think so.

Such negative aspirations are similar to what Calabrese-Barton et al. (2001) characterise as parents who perceive science to be an ‘untouchable domain’, those who think science is hard, who are afraid of science or perhaps dislike science. Such negative aspirations of some parents are also likely be linked to a complex interaction between their immigrant identity, potential negative experiences associated with it and disenfranchisement (Erel, 2010).

Overall, even for highly aspirational parents, there is high degree of variation in the way they think about potential careers and the way they communicate with their children about their aspirations. There appears to be two approaches to this. In the first approach, aspirations are formed in a limited way, which depend heavily on parents' own experience and understanding of careers. It is very rare in this approach for parents to receive advice or enrich their views by learning about contemporary career options available for their children. Also, when it is probed deeply, parental aspirations do not always align with their children's abilities, strengths and preferences. Indeed, as a result, some parents provide very general and distant advice and communicate in a non-encouraging way: "Look at us, you can be better or be just like us. You can become a doctor. You can make lots of money". For instance, Isil says that she tells her children:

> If you don't study, you will be a simple stallholder like me or a kebab seller like your father. These opportunities were not available to us.

But then her son, unimpressed, says "it was your time, things are different now". In fact, a good number of parents report that the kids don't listen really, and respond by saying things like "you always say this, OK mum, I got it, OK" when they talk about careers and future plans for their children. These conversations are not likely to be useful as there is not much exchange of ideas and experiences, or touching at real feelings and forming understanding. This first approach unfortunately does not act as a good conversion factor, nor does it help in children's capability development.

However, a second approach exists in which parents are deeply involved in their children's education. Here, aspirations are combined with involvement presented in Section 6.3.1. They know their children's favourite subjects in detail, take them to related activities and actively monitor and encourage them. When these parents talk about future plans and careers, they include personal and specific examples, and they report that their children actively listen and join in such conversations. This clearly has the potential to improve children's capabilities. As Tulay, Numan's mum put it:

> Also, we will apply NHS for a job experience for Numan. He is quite keen on medicine and we think it would be great if he could have a chance like an

> experience at NHS. So, we are not planning a holiday for this summer. We all sacrifice our summer for him.

In addition to these findings on the role of parental aspirations, a common observation is that parents all wish their children to complete university education and have a respectful job, but at the same time a significant number of them share a pragmatic and financial-focused view by highlighting the role of earning potential in a career. Bahar said:

> I always tell them 'Don't go to university just for the sake of going to university. You need to earn money, because life is money, living depends on money. Being an eye doctor, an accountant, a lawyer, these are prominent. In these, your job and earnings guaranteed. Just go to a university, it's not that different than working at a kebab shop'. I mean, I know my neighbours. Their son, he completed two universities, but now he sells simple houseware in a Poundshop.

Finally, in line with the existing literature (e.g., Sikora & Pokropek, 2012; DeWitt & Archer 2015), I find from my interview analyses that gendered differences emerge for career aspirations for boys and girls. For example, being a teacher is a very popular career aspiration for daughters, as parents think it is "ideal for maintaining a good family life" with long vacations, and relatively straightforward and regular working hours.

6.3.3. Parental science attitude as a conversion factor: Mismatch between attitudes and actions

Although I first introduced parental attitude as an initial resource, I suggest that parental attitude also works as a conversion factor and capability enabler, especially when it is activated with daily practices (e.g., conversations) and activities.

Most of the parents express positive attitudes and some kind of interest towards science and they say they like science. Even those who are uninterested mention some admiration towards science. However, when it comes to giving examples about their interest and activities, only a few parents were able to provide specific and substantive instances. The limited examples they provide include mentioning certain science-related news from the newspapers and online resources, some science shows and documentaries on TV, sharing science-related things on Facebook or other social media, or elaborating on why they admire certain scientists. However, a large majority of them cite a lack of available time ("I want to talk to him about science lessons, but I just don't have time"), a lack of available resources (such as books or magazines) or their children's lack of interest to pursue relevant science activities. So, a significant mismatch seems to exist between most parents' science attitudes and their actual actions. As a result, if positive science attitudes are not supported by actions, they are unlikely to act as a conversion factor to help develop science capabilities.

This mismatch, however, is not the case for everyone. In fact, a small group of parents not only have positive science attitudes, but they also demonstrate this in specific actions. These efforts include trying to understand what children learn in science lessons despite their lack of background and relevant knowledge, asking detailed questions about school science, their learning materials and projects, and making notable efforts to get their children involved in different kinds of learning opportunities in science such as Olympiads, competitions and fairs. For example, Numan's mother says:

> I noticed Numan is very interested in human body, diseases and their treatment. So, I thought he will love such books. I bought them from the library and online, and put them in visible places at home. He loved this.

Bahar also appears to be a parent whose actions follow her words:

> I am never the kind of mother who tells kids 'Go to your room and do your study'. I try to do things with them as much as possible, For example, museums. When they go to a museum with the school, I join them. If there are places kids want to see additionally, I take them.

In fact, this mother is so proactive that when I, as the interviewer, mentioned a specific museum in London during our conversation, she made a note and came up with a plan to visit it with her daughter, one of her friends and her mother.

My interviews revealed a significant gap between parental science attitudes and actual parental actions related to science in these Turkish immigrant parents. Previous research identified home-based and culturally-based experiences as a critical element in science education where parents' role is significant (Jegede & Aikenhead, 1999). Indeed, mothers who described having spent significant amounts of time doing science with their children have been reported to perceive science in more personal, dynamic and inquiry-based ways (Calabrese-Barton et al., 2001). As such, parental actions and working with children on science act not only as a conversion factor from resources to capabilities, but can also extend the level of initial resources and reduce the gap between attitudes and actions.

The attitude-action gap I identified during my interviews is also related to what Mickelson (1990) called the 'attitude-achievement paradox'. In her study of black youths and adults, she found that they expressed high regard for education even though their academic performance was poor. Mickelson (1990) then made a distinction between abstract attitudes and concrete attitudes, and suggested that it is concrete attitudes that inform achievement behavior which are rooted in life experience. She then highlighted the role of structure in developing concrete attitudes. While I recognise such structural limitations, my theoretical model and interview findings highlight a more nuanced picture where agency's role should not be ignored. For example, one of the mothers in my interviews, Bahar, demonstrated how parents can take a proactive role by matching common positive attitudes with real actions.

6.3.4. Physical environment as a field in science capability development

In my theoretical model, *field* (Bourdieu & Waquant, 1992) is an important element on which conversion factors act to develop science capabilities. Field provides the context in which the potentialities of the habitus are activated and individuals with similar habitus or cultural and social capital can demonstrate very different practices or positions if their fields are different (Bourdieu, 1990).

A novel finding from the interviews is the frequent mention of the role of the physical environment in which the family lives in enhancing or limiting capability development. For example, when I asked parents whether they do any simple science activities or experiments at home, several of them mentioned lack of space as an issue. One such parent responded: “I would love to. But, we have a small house and a small kitchen, where to do experiments?”. Similarly, a parent with a genuine interest on planting and gardening said: “If we had a big house with a garden, I could grow many plants, teach them to kids ... I personally have lots of interest to botanic things … Many plants are even used for making medicines …”. Physical environment is of course not independent from SES factors, which points to a complex link between SES and other potential conversion factors,

In contrast, there are examples where such structural problems are overcome by parents’ will and agency. For example, the two sisters Fulya and Derya shared the same room but their parents realised they were distracting each other with different sleep and study patterns. In order to solve this, their father spent a significant amount of time in building a nice partition to separate the room into two. Their girls’ mother, Gonca, said that the girls liked it very much, and it helped reduce their distraction considerably.

Therefore, one can consider the physical environment as a field which may or may not be conducive for the conversion factors.

6.3.5. Neighbourhood and social environment as a field in science capability development

Another important field for science capability development that emerges from the interviews is the neighbourhood and the social environment. For example, when I asked one parent if she thinks her son could do well and, for instance, become a doctor if he works hard, she responded by saying: “Maybe. With school’s support. But it is hard in here … in this neighbourhood”. Another parent responded in almost identical terms: “A big shortcoming, there is no one she can see, she can talk, she can interact with, none in the neighbourhood, none in this street”. Yet, another parent felt the same, but used different words: “Well, he does not have any good social support or good influence in here. After some time, kids just follow others and practice whatever is done by the people around them. Unfortunately, there is no one enthusiastic to study around us”.

Parents have almost entirely Turkish social circles, as most parents work independently (only a few parents have professional occupations) with no access to British friends or colleagues. Mr Fagan, a science teacher as ANS, vividly illustrates this:

> Parents have an opportunity to get out of their own culture, but in contrast they are like “Oh we came here, a different land, and found each other, and we have to stick together. Work together, go to Turkish supermarket etc”. So, they are showing their children that they only live in this way and then although their children would want to spread and have English friends and so on, they tend to only interact with other Turks. Parents don’t tend to have English friends. I had to fill in a British passport application. The son brought it to me, and he asked me ‘My dad asked if you could sign this’. ‘So, but it is not yours, it is your dad’s, I don’t know him’. And he said only ‘You know him for two years’. So, you have to show the government you know English people for at least two years to become a British citizen. You see things like that.

Also, just as is the case for their parents, most Turkish students socialise predominantly with other Turkish students both in and out of the school. A parent at ANS says:

> Well, what can you do. For kids, there are not that many (non-Turkish) people around to become friends. My daughter, she is better, she can interact with them, for example we have this neighbour’s daughter. I want to see them playing together, become friends, but see, people are distant and reserved here.

Mr. Fagan also comments on this closed friendship circle:

> The Turkish group hangs around themselves; they don't tend to have like others. Maybe it is in the lower end, I notice a lot more, being together. The groupings you know in the class. Turkish students in the top group tend to have English friends, they get on and they talk about more things like exam results. Here most students, they are learning English here and go home, and watch Turkish TV and everything around Turkish community, going to Turkish wedding party with only Turkish people. Families don't show that they have English friends and so on. So, the Turkish children, they may have British friends when they are at school but when they leave the school they tend to just go around with Turkish kids like their parents.

A parent highlights how social environment can facilitate capability development:

> If he is not friends with a doctor's child, then he feels like such a profession is unreachable, something too distant him. Then he gets discouraged and sees it as something very, very hard. But if he sees that in a friend's father, then he can more easily think this is doable, and feel I can do this too. Perhaps I am wrong but I see it this way. They don't have confidence on their abilities. I experienced this myself, in the beautician course, initially I was very hesitant thinking no way I can do this. But when you start doing, then you start asking 'Why shouldn't I do it?'. I guess it should be very similar with kids.

Indeed, another parent, Tulay, mentioned that Numan talked to their local GPs' to ask some questions on medical careers: "A few of them come from Muslim background too, so they happily answered his questions".

These interviews demonstrate how the field of neighbourhood and social environment can act as a facilitator or as a barrier in immigrant students' science-related capability development. Considering my theoretical model, neighbourhood and social environment is a field in which various conversion factors are realized and reproduced. Indeed, Bourdieu (1990) characterized field as a broad concept; it can be a higher education institution, a family, a town, a profession. The distinctive characteristics of a field are that it develops a distinct logic of its own, a natural understanding of the world and implicit and explicit rules of behaviour (Bourdieu & Wacquant, 1992). In the case of Turkish students, it appears that their neighbourhood and social environment field where they activate capitals (Vincent et al., 2012) seems to be limited, does not help them develop science-related capabilities.

6.3.6. English skills and literacy as a barrier to capability development

English skills and English literacy emerged multiple times as a major barrier to science capability development in my interviews. Communication and English language skills of students influenced by home backgrounds are suggested by multiple teachers I interviewed to be a potentially harming factor in Turkish immigrant children's science capability development, and many parents are not aware of this. The Head of Science at ANS says:

> Science literacy and English literacy are interconnected, especially when it comes to expressing understanding in exams, Turkish kids struggle. Also, most parents are not aware of this. Just because their children can speak and write in English, they assume this should not be a problem. But from teachers' perspective, it is a big problem.

One teacher at the Athenaeum School says:

> The other problem I suppose I see is that there are some homes where the only language spoken is Turkish. And the government is not going to change the exams where 20% of marks will be based on spelling, punctuation, grammar, in other words written English, and so that also sometimes hinders the progress of the student. Because they go to the home environment where Turkish is the only language, they are thinking in Turkish, speaking to Turks, but when they come back to school, when they write in English, I see problems with their English.

Similarly, the other teacher at the same school suggests: "I think literacy and vocabulary is a barrier to learning. Because now especially in the exams they have got, you know, six-mark question, they find it difficult to script a mini essay. It is problem of staying in science".

Interestingly, when asked about ways to improve Turkish minority students' success and attitudes towards science, the first thing a science teacher suggested was improving literacy:

Tuba: What kind of support do you think Turkish minority pupils need to improve their success and their attitude towards science?

> Mr Ilbert: I think it comes to making them have high expectations. That we are not making any excuses for this group of students who are not making a good progress, because they have issues with literacy. They are not strong readers and so I think so yes first level of support comes within the classroom for literacy, but maybe there is something more than that which is school and department we can do with these students. And I don't know this can be after school support and I don't know if that is just general drive doing and improving literacy for whole school.

Teachers also pointed out the difference between English speaking versus reading, writing and understanding. While students may be very good at speaking, it does not necessarily mean that they will be good at understanding, writing and reading. Mr Fagan highlights this saying:

> This is a major issue, and sometimes even teachers do not realise this easily. They speak English, but reading and writing is different and like for example because I know some Turkish, so I can understand what may be going wrong. We show the video today and one of the Turkish kids say "Can I open the light, can I open it?' and I say "No! We *switch* on light" so it is direct translation from Turkish, so although they speak English, I don't know. The teacher wouldn't pick up on that.

Interestingly, some students also mention their problems with English literacy, but surprisingly this has increased their focus in science and maths, which they think require less English. Numan says:

> I don’t like English because I have always been weak at it and I always find it very difficult and when you need to write it your own opinion, or as your own words for me it is very difficult. Why I like science and maths most is it is all factual and you play with it and use it. When it is a science coursework, writing part is sometimes hard for me. But when working on a book and we learn knowledge from the book, it is not difficult for me.

A teacher also points out communication problems with parents of the students due to poor English skills. This can result in a lack of understanding of the education system, limited involvement at school, and not knowing what is going on at school. Indeed, Isil, a parent admits:

> Well, am I happy with their school? I don’t know. Because of language you know, all we learn about school is from the children, I attended meetings few times, but that’s it. Without children’s translation, I can’t understand.

A teacher, Iclal, suggests that as a Turkish British, her ability to speak in parents’ native languages helps:

> Communication is an issue. I can speak Turkish as well. I don’t think that’s been a problem for me. But I think we need to have more often maybe an open day, a taster day, a science taster day informing parents of potential kind of future when they choose science.

She also makes an important suggestion that teachers should take the lead in trying to involve parents: “I think, the parents, they want to be involved. If we do ask, they involve, I don’t think they are reluctant”.

While I had, prior to conducting the interviews, anticipated seeing a role in the immigrant parents’ English abilities limiting their involvement and therefore limiting students’ educational outcomes, as found in the literature (Turney & Kao, 2009, Zhou & Bankston, 1996), my findings on how students’ own English abilities can affect their science capability development were somewhat surprising to me.

On the one hand, students’ English limitations in reading, writing or understanding were suggested to be detrimental for their science capability development (as repeatedly pointed out by the science teachers in my interviews). Indeed, previous research has highlighted the link between English literacy and science learning (Lee & Fradd, 1996). More interestingly, however, even if students have the oral proficiency in English and have good speaking skills, this does not necessarily indicate that they will understand the language of science, assimilate the scientific material in lessons, or become effective communicators in science. In contrast, as pointed out in a few studies and by my interviewees, students' good oral skills may mask problems in other areas of literacy (e.g., comprehension, reflection) which are more essential for science learning (Cullison, 1995; Fradd, 1995).

On the other hand, immigrant children's exposure to more than one language (both their parents'/home language and English) or even their limitations in English may influence science-related capability development in unexpected ways. For example, Kearsey and Turner (1999) found that although some immigrant (bilingual) pupils may be at a disadvantage in understanding scientific language, for others, being bilingual can be an advantage in understanding scientific language. This is because, a bilingual pupil may have a wider experience of learning and making sense of new languages, and science in effect has its own language. My interview analysis reveals another mechanism. Numan's focus on science and mathematics increased because he did not feel comfortable in English, and he felt that science and mathematics require less English compared to other subjects.

6.3.7. The role of cultural practices in capability development

Cultural practices and religious views also appear to have a strong influence on the capability development process.

An unexpected finding to me is the reported popularity of early marriage among girls. This was mentioned by multiple teachers and parents. A parent says: "All our relatives' girls, they just have their hearts into going to weddings, our girls tend to marry quickly". Similarly, one teacher comments:

> Well, from what I have seen especially year 11 girls, they are not very studious, most of them, they are not very into lessons, but they are more very

into their hair and the talk about boys and marriage. This (marriage) is sort of cultural thing. Especially for the girls. I have seen some of my past students they went to university but again they married early unlike the British group and then they are at home rather than putting it through a career. They think the main thing first of all is to get married.

Tuba: Do you think this is promoted in the family?

I think it is promoted by family. You know it is a cultural thing I think. Boys can do whatever. Boys have to have a job in order to get married. The parents are happy for them to get married, but they are not looking the longer-term picture, how are you going to support your wife and how are you going to do this, you know. And it is usually “we will help you get a house” or they stay with their families. When they need help, their families have to do this. English kids just they go off, and do whatever, they are not really into “my parents will give me this”. And this approach, I think it keeps them away from education in the sense that the community will support them and help them rather than them doing it mainly for themselves.

Early marriage of girls is clearly not confined to Turkish minority students in the UK; many ethnic minority girls including those from Pakistani/Bangladeshi backgrounds in the UK (Berrington 1994; Dale et al., 2002) and Hmongs (Lee, 2001) in the USA have been observed to marry at early ages, which then deters individuals’ educational aspirations (Drabick, 1972). The above extract also highlights the role of community and family in relation to children of immigrant parents and how relying on them may actually deter educational participation.

Certain cultural practices of the Turkish community also seem to generate integration problems by creating isolation from the rest. Mr Fagan at ANS says:

I don’t know how they are going to integrate and spread out, and break this ‘Turkish marry only Turkish’ cycle. (Laughs) But it’s true, you know. My group, so English with black skin, we can marry any people it doesn’t matter, because you know we are part of the same community. I don’t know, it is different, for most Turks.

Mr Fagan’s observations are in line with research on intermarriages among ethnic groups in the UK (Muttarak & Heath, 2010) which has found notable differences between ethnic groups with the highest rates of ethnic endogamy in Pakistanis and Bangladeshis, and much lower rates in Black Caribbeans and Black Africans. It seems likely that Mr Fagan would expect endogamy rates among Turkish people to be closer to those among Pakistanis and Bangladeshis than among Black Caribbeans and Black Africans.

Religious views were also mentioned by some interviewees as having a potential effect on science capability development. A science teacher in Athenaeum sees parents’ religious views as a potentially challenging element in teaching science to students. He says:

> There have been some parents who have come in and asked questions about certain topics in science, especially evolution. It is difficult I suppose for some parents to separate the religious views and scientific subject. When you have that in their environment, for students in science, sometimes difficult for me to teach the students about science. Because sometimes then they go home and their parents might say “It is all no, it is not correct”. It makes my job a bit more difficult because I am employed to teach the National Curriculum, it is what I have to teach. For some parents, it is difficult to separate the religious views and scientific views.

Such issues on the potential conflicts between religion and science have been identified in research where students’ cultural beliefs may be inconsistent with Western science (Jegede & Aikenhead, 1999; Reiss, 2009). In such situations, teachers can play an important role in smoothing transitions between students’ home cultures / religious views and the culture of science (Costa, 1995; Snively & Corsiglia, 2001), to help them to better learn science (Reiss, 2008).

6.4. Developing science functionings

In the theoretical model, following Sen, I outlined the distinction between science capabilities and science functionings. I argued that developing science-related capabilities is a desirable outcome and it is perfectly fine to have students with good science capabilities but with their own will they can decide not to convert these into functionings in terms of, for example, career choices. However, recent academic and policy literature in education emphasises the urgent need in our societies for individuals who are highly literate in STEM subjects and who wish to pursue STEM careers. Yet, studies consistently report most students' disinterest on these topics and science-based careers. Therefore, exploring which conversion factors may influence science-related functioning development and in which ways is worthwhile. The interviews reveal three main factors in science-related functioning development.

6.4.1. A lack of awareness of the potential use of science in various careers

My interviews suggested that many parents only know about generic science jobs and careers such as doctors and nurses, but being a scientist does not mean much to them. Also, parents generally are not aware of the importance and widespread use of science courses in gaining entry into a wide range of university degrees and in other career paths. A teacher at the Athenaeum School points to the lack of awareness in most parents for the potential use of science in other subjects and careers, saying:

> I think parents should be informed. And I think parents need to be aware that it is not just only English and Maths compulsory. And science at GCSE could potentially give them so many options at A levels and even at university … they need to be aware just because they are taking science at GCSE or A level, it doesn't mean they have to choose a degree at science. Science is an entry point and a potential to many subjects and future careers.

This concern is not confined to immigrant students, as in my study, but is a broader issue highlighted in the recent literature. For example, many parents and children have been reported as seeing jobs in science only in terms of becoming a scientist, and not really knowing the diversity of career options that can be provided by science (Archer et al., 2013). This issue might also be linked to structured factors and socio-economic status, and how certain parents may be more aware of the potential 'exchange value' of science in future career opportunities.

The comments of the science teacher at Athenaeum School very much echo Archer et al. (2012)’s call for increasing both children’s and parents’ awareness of the open and wide variety of career options available with science qualifications. That is, science education and science qualifications are not just for a career in science, but possess significant exchange potential for future employment in a variety of careers (Adamuti-Tranche & Andres, 2008; Lyons & Quinn, 2010).

6.4.2. Parental attitudes and developing science functionings

In developing science functionings, parental attitude seems to be a major driver. Irmak is a good example for this. She is a high achiever with very strong science capabilities, but when it comes to further study of science or science-based careers, she seems to not consider them at all. And this is likely a result of parental attitudes. Irmak says she likes all subjects, but maths and science are the ones that she likes the least. After further probing, it emerges that she actually enjoys science and maths, but just does not consider them as potential career paths as she wants to become a lawyer:

> I love physics, because I love like outer space and astronomy. I like learning how the world works. For example, the atomic theories, the explanations, it is a big accomplishment for the humankind. For example, I remember electrodes, the positive and the negative in an experiment. And then insulation in houses, like when you insulate the house, the lower amount of energy loss. And, last year, we also did the chemicals, and like what happens when an alkali reacts with an acid. In biology, you are a human, you can use it yourself. For example, when your heart, in a hot day it expands and in a cold day it shrinks. It is like, you can kind of understand yourself better.

Her mother, Tanem, mentions their role in influencing her aspirations with some regret:

> I believe we have influenced her. After I realised that I felt a bit sorry. But, yes, I always wanted to become a lawyer and my husband was the same. His one is a heart-breaking story, he even had gained an access to law school but

> in those days' circumstances, he had to leave. So, I believe we have imposed on Irmak's choice since she was a little girl. But also, my daughter is a go-getter so we told her that this is a proper job for you. Even now she tells us "you did this but now I really want to become a lawyer or barrister and if I couldn't do it, I would feel very sorry for that".
>
> Tuba: You said that Irmak loves physics. So, what if she chooses a related, science career, would she be able to do it? What would you think if she chooses a science career?
>
> Tanem: To be honest, maybe we influenced her. I disliked science since my childhood in secondary and high school. I think teachers have got a big role on that. I didn't like my teacher. I said I hated science, but I haven't forgotten the experiments we did in school when I was a kid. I have forgotten everything but not the experiments. Irmak, the same, she loves them. For example, Irmak told me they recently worked on a real heart in the school, she told me she cut it and looked at it in detail. She was very excited about it and told me a lot on what she learnt with this experiment.

Indeed, extant literature has highlighted the role of parental attitudes in developing students' aspirations in science (Archer et al., 2012; DeWitt et al., 2011; Keller & Whiston, 2008; Turner, Steward & Lapan, 2004). For example, in a large-scale survey study of students' aspirations between the ages of 10 and 14, DeWitt and Archer (2015) reported that parental attitudes to science is one of the two biggest predictors of students' aspirations in science.

However, one should also make a distinction between aspirations and career choices. Indeed, DeWitt et al. (2011) raised the question as to why positive attitudes and aspirations for science in immigrant children do not translate into higher education choices and careers in science, as they observed a significant mismatch between high attitudes and aspirations and low progression and attainment in science in Pakistani and Bangladeshi school students in the UK. They then rightfully raised concerns as to whether 'raising aspirations' of ethnic minority groups is the right policy action (given that these groups seem to already have high aspirations), concluding that (p.263) "it is the surrounding context and conditions of the ethnic minority groups that need to be addressed". Indeed, in the previous section where I discussed developing science capabilities, a large portion of conversion factors were tightly linked with "surrounding context and conditions" of Turkish immigrant children such as the neighbourhood, social environment, physical environment, and parental actions.

My interview analyses identify two additional points related to science progression and career choices in science, and corresponding parental influence. First, in line with my theoretical model which makes a critical distinction between science capabilities and functionings, there are students like Irmak who love physics, science and astronomy, who appear to have strong science capabilities, but do not wish to continue with science; in Irmak's case, she wants to become a lawyer. This, I would argue, is not necessarily, for Irmak, an undesirable outcome in itself if she had the necessary information about and awareness of alternative career options, and then decides that a career in law is what she wants. However, if a science career would have been more suitable, fulfilling or enjoyable for her or, to exaggerate, if she would have been the next Nobel prize winner in chemistry or medicine, but decided not to pursue science further as a result of negative parental attitudes, then this would have been a loss for society in general and science in particular. This highlights my second point, which is that highly developed science capabilities may not translate into science functionings in terms of career choices, and this could be driven by parental attitudes. Had Irmak's parents had more positive attitudes towards science, had they had science-related jobs or perhaps scientists who were friends, then, arguably, Irmak might have chosen to pursue science. This also highlights next and my third point on the influence of role models in the development of science functionings.

6.4.3. Role models in science: "They are in Turkey"

For most students and their parents, the lack of visible role models was a leading deterrent for students to develop science interest and aspirations. Almost all parents compare UK and Turkey on the availability of role models, and they unanimously conclude that Turkey is much better for having access to role models. The parents frequently mention that they have close relatives who are teachers, engineers, doctors and nurses but “they are in Turkey”. Isil, for example, notes:

> My sister is a science teacher, in Turkey… But there is no one here, doing science … no one in the family or neighbours … There is no one they can see, that’s a big drawback.

Jale similarly says:

> Our kids see people in kabab shops, barber shops, off licence shops … They cannot connect with relatives who are teachers and doctors in Turkey.

Bahar highlights another point:

> To be honest, I didn’t see very many Turkish children here who get a good education and career. I saw many more in Turkey. Because, they don’t have this comfort in Turkey, so they have to study. But in here, they have everything, so no motivation to study. For example, if my sisters were here, from seeing their cousins, my children would be more ambitious. I try to motivate them by telling about them, “look, your cousin Sena stays at school during the summer to complete her degree sooner”.

Although almost all families spend the summer holiday in Turkey, they say it is not the ideal time to talk about classes, careers and aspirations, and to get inspired or motivated. And, of course, interaction is naturally limited when they are back in the UK. When I asked a parent, Bahar, whether they exchange opinions on school/career-related issues with the relatives / role models in Turkey, she says: “They are busy there, we are busy here. It is not that helpful or meaningful when we are over the phone”.

As a result of having very few and distant role models in the UK (e.g., cousin of a neighbour, a friend’s relative), students’ exposure to role models is typically in the form of one-off discontinuous interactions, which seem to be ineffective.

My interview findings indicate the significance of close, intimate and reachable role models in influencing ethnic minority students’ science participation and career choices in science. In addition to all structural limitations and existing barriers already for children of immigrant parents (Turney & Kao, 2009), it is apparent that the 'distance' of role models who are back in Turkey poses another limitation. Indeed, recent research examining the effect of significant persons as inspirations to participation in science have highlighted that 'interpersonal relationship' is the key in inspiring and motivating students to choose STEM education and careers (Sjaastad, 2011; Rodd, Reiss & Mujtaba, 2013). Without such interpersonal and intimate connection, the role of celebrity scientists or distant role models has been suggested to be highly limited and ineffective in influencing students' science aspirations or science careers (Gilmartin et al., 2007; Buck et al., 2008).

Indeed, such personal connections could be extremely valuable for students; Ms Bailey from the ANS School shared this anecdote:

> Tuba: What do you think what are the factors that affecting formation of aspirations?
>
> Ms Bailey: I think it is seeing it. Going and seeing it. Seeing somebody you would like to be like them, reflecting back at them. So, when we have an invitee, I try to make sure a mixture of gender, that we have black and ethnic minority, that we have a Polish speaker, so we try to have an integrated group. So, they can see reflection of themselves. When we went to Cambridge for example, what was lovely about Cambridge, this is the year 7s remember, we had a pupil who is at one of the colleges of Cambridge, Roy, so he came to meet to the students, and he was the tour guide (there were 45 students). He just left us last year, he is in his first year in Cambridge, They were like AAA! And we had feedback forms, they were all like "it was hilarious", they are like "I am coming Cambridge, I will work hard", like that. And also experiencing it. We asked them before they went, you know, what do you think about Oxford and Cambridge? They said: "People who are posh, rich, super super clever", you know. When we went there, afterwards, they were like "ooh, it is all about hardworking, I can do that".

6.5. Discussion

Building on the theoretical model I developed in Chapter 3 and focusing on the outside-school factors as emphasized in Chapter 1, this chapter explored (i) initial resources, (ii) conversion factors from initial resources to capability development, and (iii) conversion factors from capabilities to functionings in Turkish minority children's science participation. While not an exhaustive list, my goal in this chapter was to empirically identify and examine critical factors that influence Turkish minority students' science-related capability and functioning development with a qualitative approach using children, parents and teacher interviews.

I first focused on initial science-related resources, or capitals, provided to Turkish immigrant students. Here, a Bourdieuian perspective was very helpful in characterising and understanding how children's parents, family and socio-cultural environment provide an initial set of resources (Bourdieu, 1990; Farnell, 2000). The first outside-school factor that emerged from my analysis as a critical resource was, perhaps not surprisingly, the role of immigrant identity. In line with Bourdieu's views (Bourdieu & Passeron, 1990; Bourdieu, 2002) suggesting potential reproduction of inequalities, my interview analysis indicates that immigrant identity as an initial resource appears mostly to constrain Turkish minority children in science participation, which has the potential to reproduce inequities. These include limited time availability of parents, lack of supportive actors and networks, and lack of parental involvement as a result of immigrant parents' limited knowledge of the educational system in the UK and limited English skills. Such factors have been outlined in the existing literature (Funkhouser & Gonzalez, 1997), with particular attention on how immigrant parents are disadvantaged in multiple ways (Turney & Kao, 2009).

In providing initial science-related capital, socio-economic status could also be critical, in that even simple economic capital has its exchange value (Skeggs, 2004) and so can be turned into other forms of capital (Bourdieu, 1986) that can potentially disadvantage ethnic minority students. After all, habitus can be considered as the embodiment of accumulated volume and composition of different forms of capital (Skeggs, 2004). However, one finding in my analysis was that parents did not view their limited SES as a major source of disadvantage for their children. While this may simply be a result of their unawareness of the potential use and exchange value of various forms of capitals (e.g., private tuition, access and network advantages), it is still encouraging that parents at least don't feel disadvantaged on the basis of SES factors.

Despite structural limitations and constraints, my findings also highlight the role of positive attitudes in Turkish minority children's science-related resources. A good number of parents in my interviews had natural and genuine interest in science which provides a very strong initial science-related resource set for the children. The role of such personal interests in providing initial resources should not be underestimated (Cleaves, 2005; Gilbert & Calvert, 2003). In fact, students can develop interest in science-related topics as a result of positive parental attitudes and genuine interest alone, as interest development begins with early childhood through play, engagement and learning (Dewey, 1979).

After focusing on initial science-related resources, I then explored conversion factors which influence science-related capability development. In my theoretical model in Chapter 3, I argued that a child may have an initial endowment of science-related capital which is acquired naturally from family environment and socio-cultural context, but that this is not the end of the story. Initial resources, even if they may be limited, can still lead to development of high science capabilities with positive conversion factors. As Sen (1992; 1993) pointed out, conversion factors through agency can be influenced by personal (e.g., physical condition, intelligence), social (e.g., norms, gender roles, societal hierarchies) and environmental (e.g., infrastructure, institutions, public goods) characteristics, which in turn can help develop capabilities.

My interview analysis identified one such conversion factor, namely positive parental attitudes to science combined with actual actions. Although not the majority, a group of parents in my interviews appear to have achieved this. Despite their low SES and limited background, as well as the other structural limitations related to being immigrant, these parents not only have positive attitudes, but also make purposeful efforts to learn and talk about their children's science lessons, engage in meaningful and curiosity developing conversations, and simply nurture their children's science interest by spending time with them through plays, conversations and other actions.

I should also note the presence of a notable number of potential negative conversion factors which emerged from my interviews. These include some parents' 'negative aspirations', that is, actively discouraging their children by communicating unrealistic, infeasible or unthinkable aspects of such aspirations, and also the physical environment (e.g., space issues at home) which also seem be to be constraining some parents from science-related activities.

Another notable conversion factor that appeared to limit these Turkish children's science-related capability development was the neighbourhood and the social environment. Many parents felt that their neighbourhood is actually detrimental to their children's capability development. In Bourdieu's terms, a field is a game with its rules which provides the context in which the potentialities of the habitus are activated (Bourdieu & Waquant, 1992). Unfortunately, the neighbourhood field for most Turkish minority students is one where 'the game' is not conducive for better development of science capabilities.

Finally, in developing science functionings in Turkish minority students in the UK, the lack of personally connected and accessible role models has been found to be a major deterrent in the conversion of capabilities to functionings. Almost all parents in my interviews compared UK and Turkey on the availability of role models, and they all thought that Turkey is much better for having access to role models, who are doctors, engineers, nurses and, at the same time, relatives and friends. Indeed, prior qualitative and quantitative analyses have found that interpersonal relationships are key factors in order to inspire and motivate choice of STEM education (Sjaastad, 2011); in the absence of such relationships, the role of distant role models is highly limited.

After gaining these initial insights into Turkish minority students' science-related capability and functioning development through qualitative analysis, I complemented this with a survey-based quantitative study. In Chapter 7, I discuss my survey findings.

7 Chapter Seven: Quantitative (survey) findings

7.1 Introduction

Building on the theoretical model I developed earlier, I prepared and conducted a survey at two schools in London with notable Turkish immigrant student populations. These are Athenaeum School[4], a relatively small independent Turkish school, and ANS, a maintained school. This survey was also translated into Turkish (details about translation, piloting and school selection are in Chapter 4), and then undertaken at five schools in Istanbul. A comparative analysis of the survey results between the UK and Turkey will be presented in Chapter 8.

In developing my survey instrument, I decided to build on previously developed and validated instruments. I also used constructs that have well established theoretical and empirical validity. My measures relating to student attitudes, aspirations and attainment were primarily drawn from the following studies: 'Is Science Me?' survey (Gilmartin et al., 2006), ASPIRES students' aspirations survey (Dewitt et al., 2010), 'The modified attitudes toward science inventory' (Weinburgh & Steele, 2000), the 'Science Motivation Questionnaire' (Glynn & Koballa, 2006) and the 'Science Opinion Survey' (Gibson & Chase, 2002). For the remaining measures, such as parental participation in science and parental attitudes to science, I developed items by trying carefully to establish construct validity. See Appendix 15 for full set of my survey questions.

The most common way to test the reliability of survey scales is to calculate Cronbach's alpha coefficients (Cronbach & Shavelson, 2004). Cronbach's alpha is a measure of internal consistency which refers to the interrelatedness of a set of items. Because this measure does not consider homogeneity, one needs to be cautious in relying on Cronbach's alpha (Schmitt, 1996). As a result, in addition to calculating Cronbach's alpha scores for my measures, I also examine elements such as inter-item correlations and check whether my measures are reliable as individual constructs. While there is no clear threshold for Cronbach's alpha scores, most

[4] All names used are pseudonyms.

researchers suggest that a value of 0.65 or 0.70 and above is acceptable (Girden, 2001), although some researchers accept smaller thresholds such as 0.60. I evaluated all my survey measures by using Cronbach's alpha scores, and report those with values greater than 0.75 as internally consistent measures. In addition, principal components analysis was conducted using SPSS to assess the validity of survey measures (unidimensionality of survey items).

Before starting to conduct surveys, I first gained informed consent of parents, teachers and students. Surveys conducted in both UK schools took place during class time, with me being present in the class while students were completing the survey. This way, I was able to assist students if they had any questions.

In addition to the brief note on the cover page of the survey, I also told students that they could skip questions or withdraw entirely from the survey if they felt uncomfortable. There were a total of 21 main sections and subsections within the survey (Appendix 15), and it took students an average of 35 minutes to complete the survey. I first conducted a pilot survey with Year 10 students at Athenaeum School to make sure questions were clear and precise, and, after this, I slightly modified the wordings of several questions. Students who participated in the pilot also participated in the main survey.

A total of 93 students participated in the survey with 51 students from Athenaeum School (55%) and 42 students (45%) from the ANS School. There were 24 Year 7 students (26%), 12 Year 8 students (13%), 16 Year 9 students (17%), and 41 Year 10 students (44%). Among the respondents, 61% were male and 39% were female.

7.2 Initial science-related resources

7.2.1 Cultural and ethnic factors: The role of being immigrant

All the students who participated in the interviews are Turkish immigrant students whose parents migrated to the UK from Turkey or Cyprus. In the survey, 43% of the students indicate their ethnic origin as mainland Turkish, 39% of them as Kurdish

Turkish and 8% Turkish Cypriot. This distribution is broadly consistent with previous reports on the Turkish minority in the UK which found that mainland Turks formed the largest subgroup of the Turkish minority in the UK, followed by Kurdish Turks and Cypriot Turks (Census 2011; Düvell, 2010; Thomson, 2006). In my analyses, I also compare these three subgroups in terms of initial resources, science capabilities, and functionings, and find no significant differences between them. I therefore analyse the three subgroups together in all my subsequent analyses.

78.5% of the students who responded to the survey were born in the UK. 42.2% of the students reported that their parents have been living in the UK for more than 20 years, 43.3% reported between 10 and 20 years, and 12.2% reported between 5 and 10 years. Only two students said that their parents have been living in the UK for less than five years. These patterns indicate that my student sample represents a quite established Turkish immigrant community with a large portion of parents living in the UK for a long time, but at the same time there are still new additions to this community, although with smaller numbers.

When students were asked about which TV channels they watch at home, 36% wrote that they mainly watch British TV, whereas 59% reported that they watch some British and some Turkish TV at home. When asked about the rest of the family, 48% reported that the rest of the family watch mainly Turkish channels, 40% reported some British and some Turkish channels, and only 13% mainly British channels. This finding suggests that almost half of the families watch mainly Turkish TV at home, which probably also affects the high percentage of students (58%) reporting that they watch some British and some Turkish TV at home. It is worth noting that, although it was not asked in the survey, my informal observations suggest that most Turkish immigrant families have only one TV at home, and it is still a common practice to watch some TV programmes together as a whole family.

Students were also asked about their parents' English language skills and how comfortable their parents are with speaking, writing and reading in English. 44% of the students indicated that their mothers are comfortable with English, whereas 39% reported their mother is neither comfortable nor uncomfortable, and 17% reported that their mother is not comfortable with English. When it comes to fathers, these percentages are higher with 67%, 19% and 13% respectively.

One section in the survey included specific questions about students' ethnic self-concept. I provide a breakdown of the students' responses in Table 7.1. It is important to note that around 70% of the students reported having a clear sense of their ethnic background and around 65% of them take part in cultural practices of their ethnic background. Around 38% of them indicated a preference for groups or organisations that include mostly people that share the same ethnic background, and 34% of them suggested that most of their friends share the same ethnic background. These numbers suggest that although a notable portion of students socialise mostly with other students of Turkish origin, there is still a good portion of them (around 27%) who state that most of their friends are not non-Turkish. Also, when it comes to roles models or mentors, students seem to have no preference whether or not they share the same ethnic background.

Table 7.1 Students' ethnic self-concept

	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
1. *I take part in cultural practices of my ethnic background, such as special food, dance, music, or customs*	26%	30%	36%	7%	1%
2. *I have a clear sense of my ethnic background and what it means for me*	36%	34%	25%	4%	1%

3. *I prefer organisations or social groups that include mostly people who share my ethnic background*	10%	28%	45%	15%	2%
4. *It is important that my role model(s) or mentor(s) share my ethnic background*	8%	11%	38%	32%	11%
5. *Most of my friends share my ethnic background*	10%	24%	39%	18%	9%
6. *People who share my ethnic background have trouble getting jobs in science in this country*	1%	8%	55%	18%	18%
7. *People of my ethnic background are well represented in science in this country*	2%	18%	53%	23%	4%

The last two questions in this section were related to students' perceptions about the interaction between their ethnic background and science careers in the UK. Students mostly do not feel that their ethnic background is detrimental factors in getting science jobs, but at the same time, about one quarter of the students think that people of their background are not well represented in science.

Overall, these findings suggest that most of the students have a strong ethnic identity which is mostly generated at home, and regenerated through interactions at home, through taking part in Turkish cultural practices and through Turkish friends. One notable finding is that television appears to be an important facilitator in this regeneration process. Half of the parents reported watching mainly Turkish TV channels at home, which is then likely to result in children joining them in watching at least some Turkish television programmes together. This then potentially leads Turkish immigrant children to keep up-to-date about things related to Turkey and to refresh their Turkish identity. This can also explain why over half the students (58%) still watch Turkish TV programmes along with British ones, despite most of them being born in the UK, with only around a third of them (36%) watching mainly British TV.

Finally, from their responses to questions about science careers and their ethnic background, students mostly think that their Turkish origin does not give them an advantage or disadvantage in getting into science careers.

7.2.2 Family socio-economic status

Students' responses to the survey indicated that most of them come from low to moderate socio-economic backgrounds. 25% of mothers were primary school graduates, 28% graduated from secondary school, 23% from high school and 24% from university or studied at the postgraduate level. Fathers on the other hand reported slightly higher educational backgrounds with 12% with only a primary school education, 30% only a secondary school education, 25% only a high school education, and 33% a university or postgraduate degree.

46% of the students indicated that they live in a council house or flat, 16% in a rented house or flat and 38% in a house or flat owned by their parents. There is a significant relationship between parents' educational backgrounds and home ownership. For example, around 40% of the home owner parents have university or postgraduate degrees, while only 3% of them have only a primary school qualification.

Most students' mothers do not work with 56% of students indicated that their mothers are housewives and another 5% reporting that their mother is unemployed. For those mothers who work, occupations include hairdresser, cleaner, teacher, nurse, and work in sewing, café shops, and restaurants. With regards to fathers, around 10% them have professional jobs such as a teacher, lawyer or professor. Those who work in the food/restaurant sector including kebab shops, fish & chip shops, pizza shops and cafés form a significant portion of employment with 32% of students reporting that their fathers work in one of these places. Although it is not easy to be certain from the survey responses, it appears that most of these parents are owners of these small businesses, rather than just being employees. Other occupations for fathers include builders, drivers, electricians, factory workers, mechanics and shopkeepers. These observations are also consistent with previous reports on the Turkish immigrant community in London (London Development Agency, 2006; Greater London Authority, 2009).

An important theme that emerged from the interview analysis in Chapter 6 was that despite coming from low to moderate socio-economic backgrounds, parents and students often said that they did not see obstacles associated with parents' educational and occupational status or financial/economic status in reaching their educational goals. That is, both parents and students think that socio-economic status has little or no direct impact on educational outcomes. I investigated this with my survey data. Specifically, I first used students' home status as a proxy for their socio-economic background and grouped them in to three categories: (i) those living in a council provided home (n=38), (ii) those living in a private rental home (n=13), and (iii) those living on a home owned by their parents (n=33). I then investigated the differences between these three groups in terms of various science and educational outcomes. In the below analyses because the distribution of the relevant scores were sufficiently close to a normal curve, I used one-way ANOVA instead of the non-parametric Kruskal-Wallis test. For subsequent analyses, I continue to use one-way ANOVA for measures with normally distributed scores and use Kruskal-Wallis test for measures with non-normal distributions. My analyses using one-way ANOVA indicated that there was no statistically significant difference between mean scores of the composite variables of *school science* ($F=0.694$, $p=0.502$), *science aspiration* ($F=0.989$, $p=0.377$), *science self-concept* ($F=0.524$, $p=0.594$) and *interest in science* *activity* (F=0.324, p=0.724) between the three groups. In addition to comparing three groups, I also conducted post-hoc Bonferroni tests for pairwise comparison of the three groups' means. This again revealed no significant differences between the groups in terms of the average scores for *school science, science aspiration, science self-concept* and *interest in science activity.*

In addition to grouping students by where they live, I also used parents' educational levels and examined their potential association with science outcomes. For this, I used five categories by using the highest educational level attained by one of the parents: primary school, secondary school, high school, university and postgraduate. I then used the one-way ANOVA test to compare the average scores of these five groups in terms of *school science, science aspiration, science self-concept* and *interest in science activity.* I again observed no statistically significant difference between the groups' averages for *school science* (F=1.541, p=0.200), *science aspiration* (F=1.744, p=0.151) and *interest in science activity* (F=1.092, p=0.368). However, this time there was a significant difference between the five groups' averages for students' science self-concept (F=6.798, p<0.001). Average self-concept scores for the groups were as follows: primary school=2.81, secondary school=3.31, high school=3.61, university=3.91, and postgraduate=4.1 which shows a clear increasing pattern in students' self-concept as their parents' education level increased. I further investigated pairwise differences by conducting post-hoc Bonferroni tests and found that the relationship held (students whose parents have higher educational background also have higher science self-concept), except for primary vs secondary, secondary vs high school, and university vs postgraduate degrees.

Finally, I grouped students into two categories, those whose mothers are unemployed or housewives (about half of the sample), and those whose mothers work. I then compared averages of these two groups for *school science, science aspiration, science self-concept* and *interest in science activity.* Using one-way ANOVA, I found that there is no significant difference between the two groups for all of the above-mentioned factors except *interest in science activity* which is slightly higher for students whose mothers are housewives or unemployed (mean score=3.43) compared to students whose mothers work (mean score=3.10) (F=3.188, p=0.078).

This may be because mothers who are at home may have slightly more opportunities (including time) to increase their children's interest in science activities.

Overall, these findings are mostly consistent with the interview results, suggesting that family socio-economic status is indeed not directly related to most science-related outcomes. It is only self-concept in science which appears to be higher in students whose parents have higher educational backgrounds.

7.2.3 Parental science attitude as an initial resource

When students responded to questions about their parents' science interests, 66% of them stated that their parents think science is interesting, 23% were neutral and 11% indicated that their parents do not find science interesting. In addition, 58% of them responded that their parents would be happy if they became a scientist when they grow up. When it gets to their parents' thoughts on the importance of science, a large majority of the students (78%) indicated that their parents think it is important for them to learn science. The difference between the responses to the statements 'my parents/carers think science is interesting' and 'my parents/carers think it is important for me to learn science' suggests that some parents who do not necessarily find science interesting nevertheless think that it is important for their children to learn science. These findings are also consistent with my classification that emerged from the interviews where I observed three groups of parental science attitudes: *genuinely positive*, *pragmatic* and *non-positive.*

One-way ANOVA examination indicated that parents' science attitudes do not differ significantly across the three groups of where students live (council, rent, owner parents); however, there appears to be a significant positive relationship between parents' science attitudes and their educational levels ($F=3.039$, $p=0.023$) with average composite scores of parental science attitudes 3.20, 3.65, 4.08, 4.21, 4.12 for primary school, secondary school, high school, university, and postgraduate degrees respectively. A post-hoc Bonferroni test indicated that this difference is statistically significant ($p<0.05$), particularly for parents with primary school vs university and postgraduate degrees.

It is also interesting to note that although 45% and 37% of parents who have been living in the UK for more than 20 years or for 10-20 years, respectively, were said to be strongly interested in science, this percentage greatly decreased to 19 % for parents who have been living in the UK for less than 10 years. When I further investigated this observation with a one-way ANOVA test and compared average parental science attitude scores between the three groups of students depending on how long their parents lived in the UK (>20years, 10-20 years, <10 years), I found that there is indeed a statistically significant relationship between parental science attitudes and how long they stayed in the UK. Average parental science attitude score was 3.92, 3.96 and 3.24 respectively for parents living in the UK for >20years, 10-20 years, and <10 years. One-way ANOVA and Bonferroni tests indicated that parents who have been living in the UK for more than 10 years have higher science attitudes ($F=3.013$, $p=0.035$) compared to parents living in the UK less than 10 years. This result is interesting and was not anticipated. One possible explanation for this finding could be that parents who have been living in the UK for more than 10 years might be able to more easily communicate their science interest with their children whereas more recent immigrant parents may be having difficulty in demonstrating any science interest they have. This difficulty might be due to the fact that their children's conception of science mostly comes from the school and is communicated in English whereas their science conception as parents is likely to be in Turkish. An alternative explanation could be that overall science attitudes may be more positive in the UK than in Turkey, so the longer the parents have been in the UK, the more positive they may be about science. I investigate this in further detail in Chapter 8.

7.2.4 Beyond structural limitations: A capability perspective

My survey results indicated that cultural and ethnic factors are an integral part of students' identities. However, most students do not feel that their ethnic background generates structural limitations on what they can achieve in science (only 10% of the students agreed with the statement 'people who share my ethnic background have trouble getting jobs in science in this country'). Similarly, family socio-economic status appears to have quite a limited effect on students' science outcomes, which is also consistent with the interview findings. I next explore the development of science capabilities.

7.3 Developing science capabilities

Building on my theoretical framework, which made a distinction between capabilities and functionings based on Sen (1993, 1999), I first focus on the development of science capabilities in Turkish immigrant children. A key construct I develop from the survey items is the measure *science capability*. It is a composite measure which included six items on science self-concept based on existing literature (Oliver & Simpson, 1988; Beghetto, 2007) ('I do well in science', 'I find science difficult', 'I am just not good at science', 'I learn things quickly in my science lessons', 'Science is easy for me', 'No matter how hard I try I cannot understand science') and four items that I developed myself based on my theoretical rationale for this measure ('If I really like a toy, I can take it apart and see the parts inside it', 'If I like an experiment during a science class, I can masterfully conduct it', 'When I learn an interesting science topic at school, I can learn more about it at home', 'If I decide to become a scientist or have a science-related job in the future, I am sure I will be very good at it.'. Notice that these items focus on the capabilities, that is, 'the ability to achieve' science rather than the outcomes in science which is consistent with the distinction between capabilities and functionings Sen (1993, 1999). I examined internal validity and unidimensionality of this measure using Cronbach's alpha and principal components analysis. Cronbach's alpha score for this measure was 0.781, indicating high internal validity. In addition, using factor analysis and 'varimax' as the method of factor rotation on the questionnaire responses, *science capability* was one of the emergent components. As one can see from Figure 7.1, science capability scores follow a normal curve with a mean of 7.03 and standard deviation of 1.29.

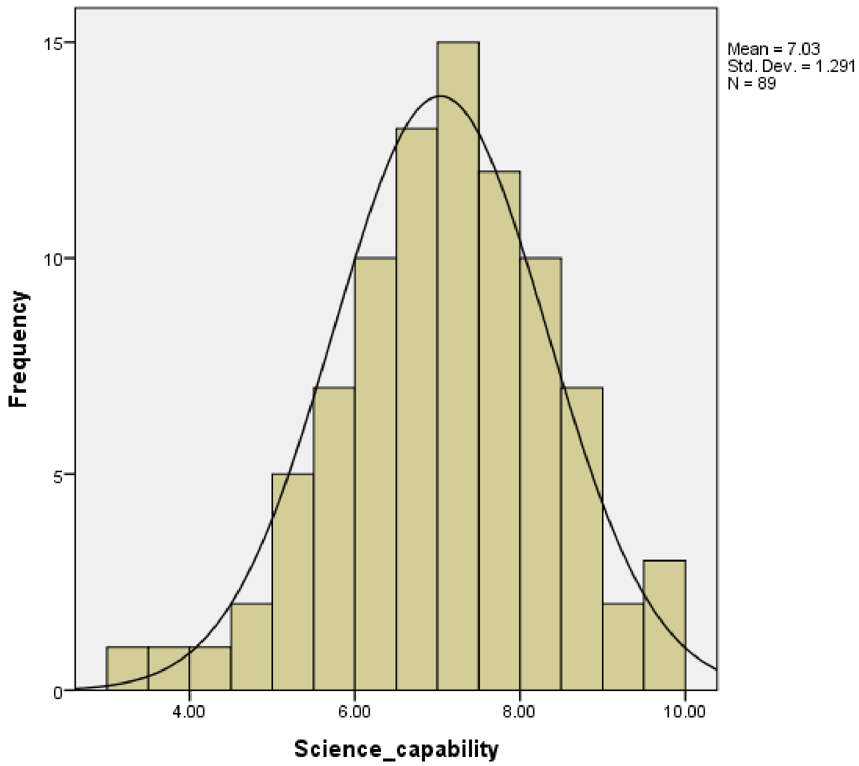


Figure 7.1 Science Capability Score

One-way ANOVA test revealed that boys and girls do not differ significantly on science capability scores (F=0.813, p=0.370). However, equivalent analyses showed that UK-born students on average have slightly higher science capabilities (science capability score=7.19) than non-UK born students (science capability score=6.47) (F=4.565, p=0.035). In addition, although students' science capability scores do not depend on where they live (council, rental, owner) (F=0.872, p=0.422), I found that their science capability scores vary significantly depending on parents' educational levels (F=4.581, p=0.002). Specifically, average student science capability score for parents with only primary education is 6.03, with only secondary education is 6.65, with only high school education is 7.04, with a university degree is 7.63, and with a postgraduate degree is 7.92, which shows a clear increase of science capability as parents' education levels increase. Post-hoc Tukey and Bonferroni tests also confirmed significant pairwise differences in science capability scores between parents with only primary/secondary education and parents with university/postgraduate degrees (p=0.025, p=0.009, p=0.091, p=0.032 for each of the four pairs).

Finally, I use the distribution of science capability scores to divide students into three groups: students with high, moderate or low science capabilities. This not only helped facilitate univariate analyses, but it also simplified the conceptual understanding of this measure. Students with science capability scores greater than 8 were classified as ‘high science capability’, those with scores between 6 and 8 were classified as ‘moderate science capability’, and those with scores less than 6 were classified as ‘low science capability’. These values represented natural cut-off values from the distribution of the scores. Using this classification, roughly 20% of students were grouped into high, 50% of students were grouped into moderate, and 30% of students were grouped into low science capability.

7.3.1 Parental involvement (general)

A large majority of students reported that their parents know how well they are doing at school (27% strongly agree, 63% agree), and they mostly reported that their parents attend parents’ evening at school (22% strongly agree, 37% agree). However, when it comes to helping students doing their homework, 30% of parents were reported not to help their children. Nevertheless, most students reported that their parents ask detailed questions about their school lessons (23% strongly agree, 38% agree).

Using the classification I derived earlier for students of high, moderate and low science capability groups, I examined the relationship between general parental involvement and students’ science capabilities, and found that high capability students have significantly higher parental involvement (score=4.018) compared to low capability students (score=3.467) (p=0.020). Notice that here I focus on parents’ general involvement with students’ education and not necessarily their science-related involvement. I examine their involvement in science-related activities in Section 0.

7.3.2 Parental aspirations as a conversion factor

Almost all students agree with the statement that their parents want them to go to university (83% strongly agree, 13% agree) and they also state that it is important for their parents that they get good marks at school (82% strongly agree and 17% agree). Such a high percentage of positive aspirations makes it infeasible to statistically examine the relationship between parental aspirations and students' capability development.

The high percentages in the surveys appear to be in contrast with my earlier observations from the interviews. My interview analyses in Section 6.3.2 revealed a larger variation in parental aspirations with high and low aspirations as well as with a notable group of parents demonstrating what I called 'negative aspirations'. That is, without perhaps even realising, some parents seemed to be actively discouraging their high-aspiration children by highlighting difficulties in those aspirations. However, in contrast, in the survey, almost all students responded quite positively about their parents' aspirations for them. While further research is needed to fully explain this discrepancy, I think one explanation could be that students' survey responses may be less genuine and more "politically correct" when a question asks how their parents think or feel.

The contrast between survey responses and interviews also highlight an important benefit of the mixed methods approach in my study. If I had conducted only surveys, I would have observed that almost 97% of parents want their children to go to university and I might have concluded that Turkish immigrant parents have high aspirations for their children. However, my interviews with parents and children provided a richer and a quite different picture where a good number of parents actually demonstrate 'negative aspirations' for their children which in turn hinders their capability development.

7.3.3 Parental science attitude as a conversion factor: Mismatch between attitudes and actions

A key point I made as a result of my interview analyses in Section 6.3.3 was the potential mismatch between parents' attitudes towards science (which is mostly positive) and their actual actions and activities which seem to be quite limited. I suggested that such a mismatch could be acting as a barrier towards students' science-related capability development. I further explore this in my survey analysis. Firstly, while almost all parents I interviewed appeared to have positive attitudes towards science, my survey results provide a less enthusiastic picture. In Table 7.2, I present a detailed breakdown of students' responses on parental science attitudes. Notice that a notable portion of students think that their parents do not find science interesting (34% neutral, disagree or strongly disagree). Similarly, a significant percent of them do not believe their parents would be happy if they become a scientist one day (41% neutral, disagree or strongly disagree). These findings suggest that parents may be less enthusiastic about science than they appear to be during my interviews with them, or perhaps children do not know about or strongly feel about their parents' positive science attitudes because they are not communicated to them or not translated into actions by their parents.

Table 7.2 Parental attitudes towards science

	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
My parents think science is interesting	27%	39%	23%	8%	3%
My parents would be happy if I become a scientist when I grow up	24%	35%	31%	8%	2%

My parents think it is important for me to learn science	36%	42%	15%	7%	0%

I next investigate the relationship between *parental science attitudes* and students' science capabilities using a one-way ANOVA test. I used the three survey items in Table 7.2 to create a composite parental science attitude measure that had a satisfactory Cronbach's alpha score of 0.762. I then examined whether there are significant differences between the three science capability groups I created earlier (low, medium, high) in terms of their parental science attitudes. The high capability group has a mean parental science attitude score of 4.42, medium capability students have a mean score of 3.79 and the low capability group has a mean score of 3.16, and these differences are significant ($F=15.318$, $p=0.000$). Further analysis with pairwise Bonferroni tests also confirmed this with a significant difference in parental science attitudes between the high and medium capability groups ($p=0.002$) and a similarly significant difference between the medium and low capability groups ($p=0.008$).

In light of my interview findings that suggested a potential mismatch between parental science attitudes and students' science-related activities with parents, I first examined the role of *parental science activities* on students' capability development in the survey. In the survey, in order to measure students' science-related activities with parents, I prepared a list of 'yes'/'no' questions asking whether they have been involved in these activities with their parents in the past 12 months. These questions included items such as visiting a science museum or a science fair with parents, watching a science-related programme or a movie with parents, receiving a science-related gift, a toy, magazine or a book from them, among others (the full questionnaire is in Appendix 15). I then counted the number of positive ('yes') responses to measure students' science activities with parents. Next, I examined the three science capability groups in terms of the differences in their parental science activity scores with a one-way ANOVA test. The high capability group has a mean parental science activity score of 2.64, medium capability students have a mean score of 2.29 and the low capability group has a mean score of 1.11, and these differences were significant ($F=5.361$, $p=0.006$).

I finally investigated the role of mismatch between *parental science attitudes* and *parental science activities*. To help with calculation and interpretation, I first grouped students into 'positive/non-positive' parental science attitude and 'high/low' parental science activity categories. I am particularly interested in the difference between 'positive parental attitude, high parental activity' and 'positive parental attitude, low parental activity' groups in terms of their science capabilities. If I observe a significant difference in these groups, this will then support my interview finding in Section 6.3.3, which suggested that "if positive science attitudes are not supported by actions, they are unlikely to act as a conversion factor to help develop science capabilities".

First, I grouped students into positive parental science attitude (45%, students who agree or strongly agree with survey items in Table 7.2) and non-positive science attitude groups (55%, students who are neutral, disagree, or strongly disagree to questions in Table 7.2). Secondly, according to the distribution of parental science activity scores which ranged from 0 to 6 with a natural cut off value of 2.18, which is the mean (Figure 7.2 shows the distribution of parental science activity scores), I grouped students into two categories, those with high parental science activities (41%) and those with low parental science activities (59%).

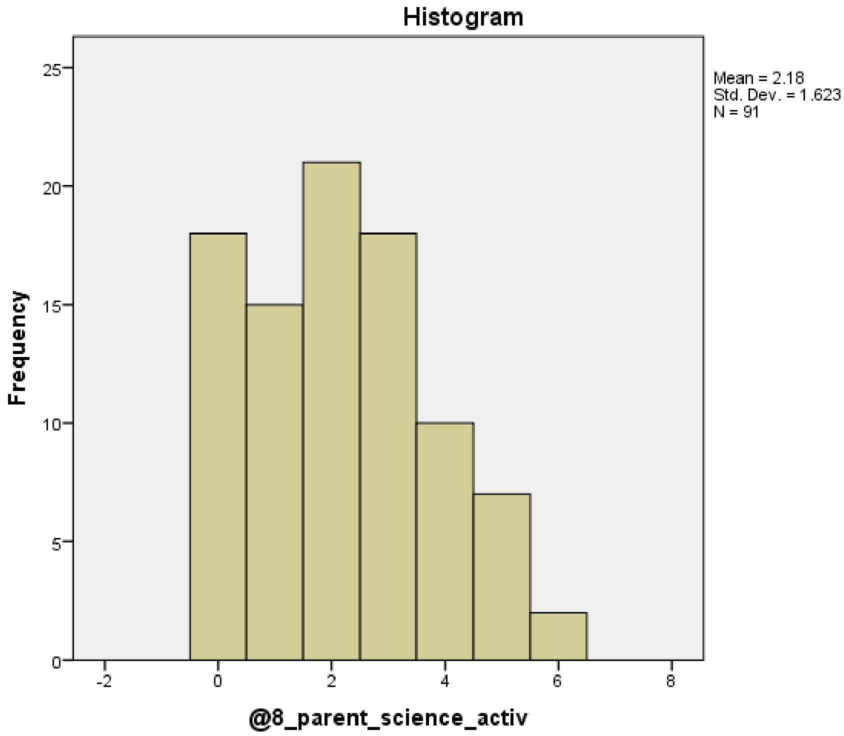


Figure 7.2 Parental sciecne activity

I then created two groups as outlined above: 'positive attitude, high activity' and 'positive attitude, low activity' groups. I then compared mean *science capability* scores of these two groups using one-way ANOVA test. While the average capability score for 'positive attitude, low activity' group is 7.19, the average capability for 'positive attitude, high activity' group is 7.72, and this difference is significant (F=4.137, p=0.029). Finally, I used the three science capability groups I developed earlier to examine how 'positive attitude, high activity' and 'positive attitude, low activity' are represented in different science capability groups and whether these significantly differ from each other. Indeed, 'positive attitude, high activity' students are proportionally over-represented in the high science capability group (61%) compared to the medium science capability group (46%) with a statistically significant difference (p=0.04) confirming my previous results.

7.3.4 Physical environment as a field in science capability development

An emergent theme in my interviews was parents' highlighting of the physical space they live in and how it may limit certain science-related activities such as gardening or experimenting with things in the kitchen. As mentioned earlier, 46% of the students in my sample indicated that they live in a council house or flat, 16% in a rented house or flat and 38% in a house or flat owned by their parents. When I compared these three groups in terms of their science capabilities, I found no statistical difference between them ($F=0.872$, $p=0.422$). This finding, however, could be due to my limited data on students' living environments. After all, I only have very high level information on council, rent, and owned accommodation, and I do not, for example, know whether they live in a house or a flat, nor the size of their living space. Clearly, a council house could be more spacious and have a garden, whereas an owned flat could be quite small and may lack access to a garden. In the absence of such detailed information, I think my earlier interview findings provide a more accurate picture about the potential role of the physical environment in science capability development.

7.3.5 Neighbourhood and social environment as a field in science capability development

For Turkish parents, neighbourhood is a critical element in students' capability development. Specifically, a large number of parents in my interviews highlighted neighbourhood as a very important barrier for their children's capability development, stating how the neighbourhood shapes their motivation and enthusiasm for science in a highly negative way.

Fortunately, I had a chance to investigate the relationship between students' neighbourhood and their science capabilities with my survey data. While I did not plan this analysis originally, one of the questions in the survey involved asking students for their postcodes. Out of 93 students, 70 of them reported their full postcodes (75%). I then used the Department for Communities and Local

Government's English indices of deprivation (2015) database[5] in which I was able to match the postcodes I collected from surveys with the corresponding deprivation index from the government database. The deprivation index is a composite measure that combines information from seven domains to produce an overall relative measure of deprivation. The domains include: Income Deprivation, Employment Deprivation, Education, Skills and Training Deprivation, Health Deprivation and Disability, Crime, Barriers to Housing and Services, and Living Environment Deprivation. (The English Indices of Deprivation (2015) research report[6] provides details of the deprivation index and its components.)

Therefore, for each of the students who reported his/her postcode, I was able to identify their neighbourhood and corresponding deprivation indices. The first decile corresponds to the most deprived 10% (decile) of neighbourhoods in England. That is, the lower the decile number, the higher the deprivation in the neighbourhood. Figure 7.3 provides the deprivation deciles of Turkish immigrant children in my sample who reported their full postcodes. As expected, Turkish immigrant children in my sample are more likely to live in deprived areas than England's average with most histogram values in Figure 7.3 falling in the first five deciles. More specifically, 10% of the students in my sample live in the most deprived 10% of neighbourhoods (1st decile), 37% live in in the most deprived 20% (1st and 2nd decile), and 63% of students in my sample live in the most deprived 30% (1st, 2nd and 3rd decile) of neighbourhoods in England.

5 http://imd-by-postcode.opendatacommunities.org/

6 https://www.gov.uk/government/publications/english-indices-of-deprivation-2015-research-report

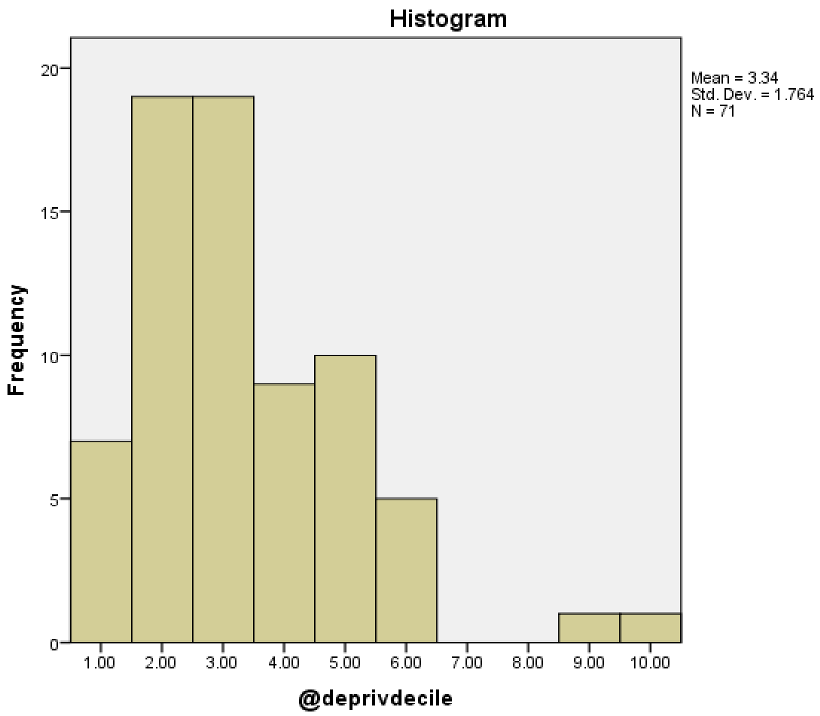


Figure 7.3 Deprivation deciles for reported postcodes in the sample

I then compared the three groups of low, medium and high science capability students and their average deprivation deciles using a one-way ANOVA test. The difference in group averages were quite small and not statistically significant. While high science capability students have a mean deprivation decile of 3.55, medium capability students have a mean deprivation decile of 3.29, and low capability students have a mean deprivation decile of 3.00 ($F=0.326$, $p=0.723$). One can also see this from Table 7.3 which indicates that there is no significant pattern in deprivation deciles according to capability groups. That is, each of the three capability groups comprise students who live in highly deprived areas as well as students who live in less deprived areas. Therefore, overall, I do not find any statistical association between students' neighbourhoods (in terms of the deprivation in the area) and their science capabilities.

Table 7.3 Students' deprivation deciles by science capability groups

		Deprivation decile								Total
		1.00	2.00	3.00	4.00	5.00	6.00	9.00	10.00	
Science capability	High	1	5	6	4	2	1	0	1	20
		5%	25%	30%	20%	10%	5%	0%	5%	100%
	Medium	6	9	9	4	5	4	1	0	38
		16%	24%	24%	11%	13%	11%	3%	0%	100%
	Low	0	4	4	0	2	0	0	0	10
		0%	40%	40%	0%	20%	0%	0%	0%	100%

At first glance, this finding appears to be in contrast with my interview results where parents highlighted potential detrimental effects of the neighbourhood and social environment on children's science-related capability development. However, in a broader perspective, these results support one of the key theses in my dissertation in that students' science capabilities are not just driven by just structural factors such as their socio-economic status (i.e., initial capital) or the neighbourhood that the children live in (i.e., the field), but agency can play a significant role in developing science capabilities. Indeed, my survey analyses revealed that high, medium or low science capability students do not differ significantly in terms of their neighbourhoods. In fact, a significant portion of high capability students (30% of all high capability students) live in highly deprived neighbourhoods (i.e., in the most deprived 20% areas). All this suggests that, despite structural limitations such as living in a highly deprived area, students can still develop high science capabilities. In addition, although there may be some truth in parents' criticism and blame of the neighbourhood in limiting their children's capability development in interviews, one needs to be cautious in taking such data at face value. It may as well be the case that structural limitations such as a deprived neighbourhood may be easier to identify by the parents compared to more nuanced agency elements such as the lack of positive science attitudes or parental science-related activities.

7.3.6 English skills and literacy as a barrier to capability development

During my teacher and parent interviews, both students' and parents' English language skills have been emphasised as an important factor affecting students' science-related capability development. Concerning parents' English language skills, many parents during the interviews acknowledged their limitations and mentioned that this restricts their ability to get involved in school or science-related activities or engage in meaningful conversations with their children. Consequently, using survey responses, I first explored the association between parents' English language skills and children's science-related capabilities. Indeed, parents' English language skills (as measured by students' responses to the five-point Likert scale question: my mother/father can speak, read, and write in English comfortably) differed significantly across the three (low, medium, high) science capability groups. Average English language score for [father, mother] for the high capability group is [4.286, 3.727], for the medium capability group is [3.761, 3.553], and for the low capability group is [3.235, 2.706]. A one-way ANOVA test comparing these group averages indicates that these differences are significant for fathers ($F=4.507$, $p=0.014$) and for mothers ($F=4.925$, $p=0.010$). That is, the higher the parents' English languages skills, the higher their children's science capability groups. These findings support my interview results, which suggested that parents' English language skills play a significant role in supporting or obstructing student's capability development.

I next explored the role of students' own English language skills in their science-related capability development. Here, my interview findings were somewhat mixed. On the one hand, two science teachers' and a Head of Science I interviewed in two schools contended that students' limitations in English are likely to limit them in science. The Head of Science at ANS said, "science literacy and English literacy are interconnected, especially when it comes to expressing understanding in exams, Turkish kids struggle", and one science teacher said "I think literacy and vocabulary is a barrier to learning. Because now especially in the science exams they have got, you know, 6-mark question, they find it difficult to script a mini essay. It is problem of staying in science". On the other hand, some students I interviewed mentioned that because they struggle in English, this has actually increased their attention and focus in science and maths, which they think require less English.

In the survey, I did not have detailed measures (self-reported or otherwise) of students' English language skills or literacy. However, there was one question in the survey that asked students about the TV channels/programmes they watch at home. When I examined the association between students' TV watching language and science capability groups, I observed that while 55% of students in the high capability group watch mainly British TV, this percentage is much lower for medium and low capability groups with 26% and 33% respectively (see Table 7.4 for details). Indeed, science capability appears to vary significantly across TV watching groups ($F=3.538$ $p=0.034$) according to a one-way ANOVA, with mainly British TV watchers having a higher average science capability than some British some Turkish watchers, which is also higher than mainly Turkish watchers.

Table 7.4 Students' TV watching by science capability groups

		TV Watching			
		Mainly British	Some British Some Turkish	Mainly Turkish	Total
Capability_group	High	12	10	0	22
		55%	45%	0%	100%
	Medium	12	29	5	46
		26%	63%	11%	100%
	Low	6	11	1	18
		33%	61%	6%	100%

Although students' TV watching language may not be the ideal measure of their English language skills and literacy, in the absence of more accurate and detailed measures in my survey, I investigated its association with students' science capabilities. My statistical analyses pointed out that students' TV watching language appear to relate to their likelihood of having a particular level of science capability. This finding is also in line with my previous interview observations in which many science teachers pointed out a potentially significant link between students' science capabilities and their English literacy skills. I think the relationship between English literacy and science capabilities is a very interesting phenomenon and future research can further investigate this with more granular measures.

7.3.7 The role of cultural practices in capability development

I consider two aspects of cultural practices in relation to students' science capability development. The first one is related to cultural and ethnic factors, practices as well as dispositions that are related to Turkish immigrant identity. I was particularly interested in examining any potential relationship between students' self-concept and activities related to cultural and ethnic background and their science capabilities. For this, I used students' responses to questions 1, 2, 3 and 5 in Table 7.1 to calculate a composite score for cultural and ethnic self-concept (I do not use their responses to other questions to ensure unidimensionality and acceptable Cronbach alpha levels). I then compared the three science capability groups in terms of their average cultural and ethnic self-concept scores using one-way ANOVA. Cultural and ethnic self-concept appears to vary significantly between capability groups ($F=5.354$, $p=0.006$). In particular, post-hoc Bonferroni test indicated ($p=0.005$) that students in the high science capability group on average have significantly higher cultural and ethnic self-concept scores (mean score=3.773) than students in the low science capability group (mean score=3.131). Therefore, far from being a barrier, it seems that students' cultural and ethnic self-concept (e.g., taking part in cultural practices related to background such as food, dance, music, customs; having a clear sense of ethnic background, having many friends of the same ethnic background etc.) is positively associated with their science capability levels. Such resources, while culture or religious specific, might contain and represent wider cultural and social capitals of students, which in turn might be associated with greater 'exchange value' (Skeggs, 2004) and greater capability development.

The second aspect of cultural practices I considered in my survey analysis was students' general cultural dispositions, cultural goods and activities that are not specific to their Turkish immigrant background but more general, as in Bourdieu's (1986) cultural capital. However, because I primarily focus on active cultural actions and practices as well as dispositions and cultural goods, my characterisation could be viewed as more dynamic than Bourdieu's cultural capital which is primarily structurally generated. Consequently, I created a new measure called *cultural activity* which is based on (i) *the number of times they visited a museum, historical site or art gallery in the past 12 months,* (ii) *the number of times they attended a play, concert* *or a live show in the past 12 months,* (iii) *number of hours they spend in a week in cultural lessons/activities outside of school (music, art, dance, language, etc) and* (iv) *the number of hours they spend in a week reading a book.* Because students' responses varied considerably to these questions, with a large number of them reporting values at or close to 0 for some questions, and only a small number of students reporting very high values, the distribution was highly left skewed. I therefore first log transformed individuals scores to the four items outlined above, before normalising and adding them to calculate composite cultural activity scores. Finally, using these composite scores, I created three cultural activity groups: students with high cultural activity levels (18%), students with medium cultural activity (51%) and students with low cultural activity (31%). The three groups' average science capability scores were significantly different according to the one-way ANOVA test ($F=6.508$, $p=0.003$) with students with high cultural activity having an average science capability score of 8.076, those with medium cultural activity having an average science capability score of 7.229 and those with low cultural activity having an average science capability score of 6.437. I also present the relative representations of high, medium and low cultural activity groups in the three science capability groups in Table 7.5. Supporting the one-way ANOVA test results, I observed that the high science capability group has a higher percentage of high cultural activity students (29%) compared to the medium capability group (18%) and the low capability group (0%). Similarly, while there is no high cultural activity student in the low science capability group, 60% of low capability students come with low cultural activity levels. These findings suggest a significant association between students' cultural activity and their science-related capabilities.

Table 7.5 Students' cultural activity levels by science capability groups

		Cultural Activity Level			Total
		High	Medium	Low	
Science Capability Group	High	6	9	6	21
		29%	43%	29%	100%
	Medium	6	13	14	33
		18%	39%	42%	100%
	Low	0	6	9	15
		0%	40%	60%	100%

7.4 Developing science functionings

According to my theoretical model, there is an important distinction between students' science capabilities and their science functionings as observed in outcomes such as science aspirations. I argued that some students with high science capabilities may not have, for example, high science aspirations, and if this is a result of their free will and own reflections, it is a perfectly fine outcome. Yet, I am interested in identifying any potential conversion factors that may help facilitate science-related functioning development in students. After all, students' lack of interest in STEM careers is a pressing issue in many developed countries including the UK. So, if certain factors facilitate conversion of students' science-related capabilities into science-related functionings, then these would be highly useful to identify for policy purposes. My interview analysis identified three primary factors associated with Turkish immigrant children's science-related functioning development. These were: a lack of awareness of the potential and practical use of science in various careers; parental attitudes towards science aspirations; and a lack of role models to demonstrate feasibility and achievability of science careers.

Before exploring these further, I first focus on the primary variable I have related to science functioning, which is science aspirations.

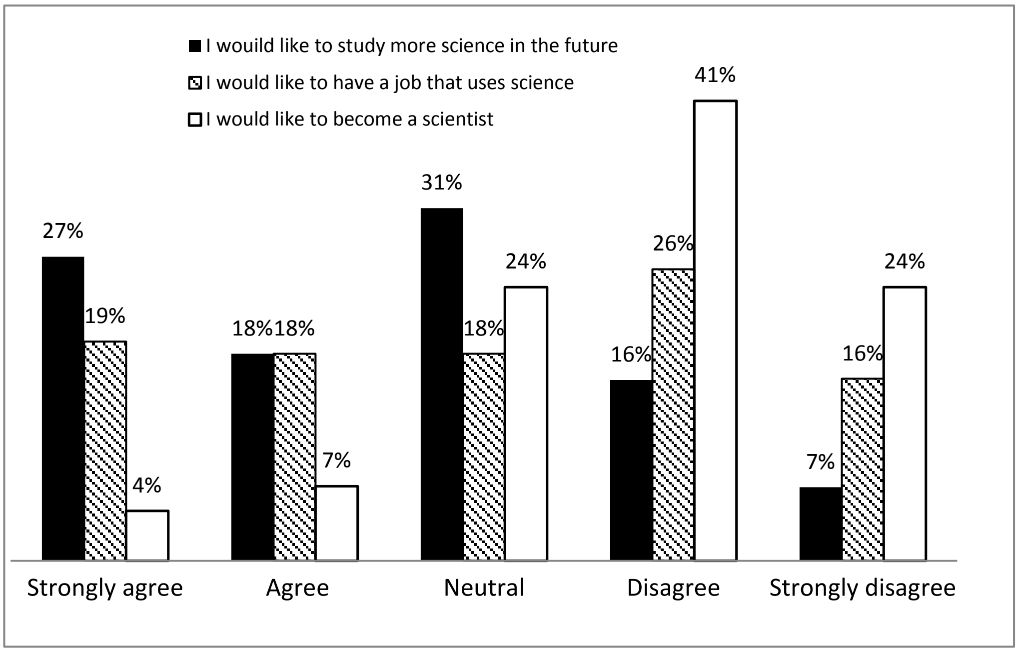


Figure 7.4 Students' science aspirations

Figure 7.4 presents students' answers to various questions related to science aspirations. As one can see from the figure, while 45% of students (strongly agree or agree) would like to study more science in the future, 37% would like to have a job that uses science, and just 11% would like to become a scientist.

Using these and other related questions (see questionnaire detail in Appendix 15), I calculated a science aspiration score. I also checked the internal validity of this measure by examining the Cronbach's alpha score, which was equal to 0.869, and therefore highly satisfactory.

I then examined the relationship between science capability scores (maximum possible range 0 to 10) and science aspirations scores (maximum possible range 0 to 5). These two have a significant and positive correlation with a correlation coefficient of 0.520 which was significant at the 0.01 level. I also plotted these two scores in Figure 7.5 to get a better understanding of the relationship.

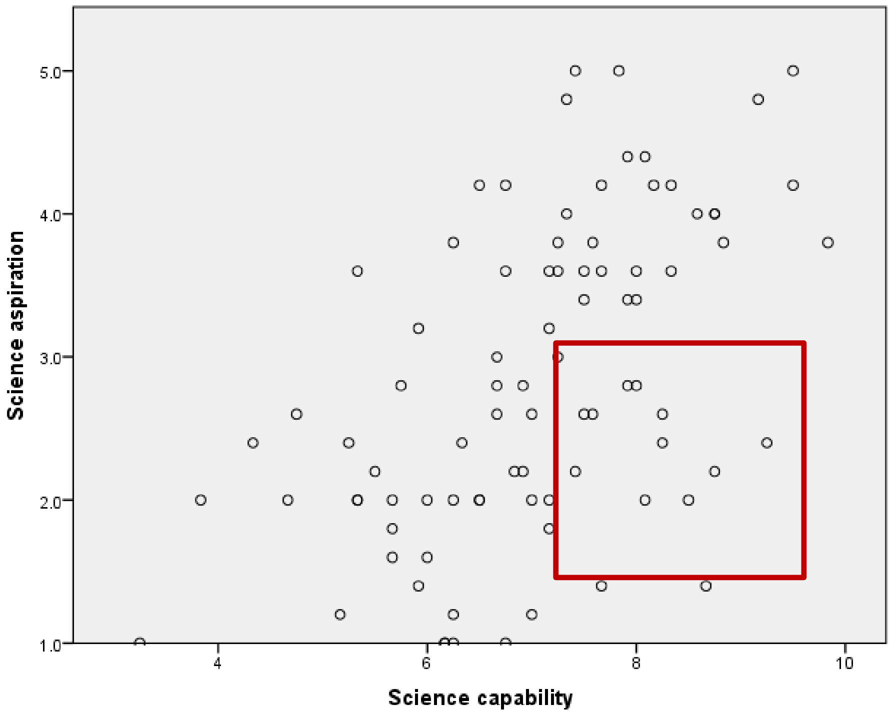


Figure 7.5 Scatterplot of science capability and science aspiration

As one can see from the scatterplot, while there is a clear positive relationship between science capability and science aspiration as expected, I observe a notable number of students in the lower right corner of the plot (the area inside the red box) which suggests that there are indeed some students with high science capabilities but low science aspirations. On the other hand, there are (almost) no observations with low science capabilities and high science aspirations (on the upper left corner) in the plot. Both of these observations are in line with my theoretical model. That is, there is an important distinction between science capabilities and science functions, and science-related functioning development is a two-stage process in which students first develop science-related capabilities and then they may or may not develop science-related functionings.

I next explore the themes that can affect science-related functioning development which emerged in my interviews in Chapter 6. One finding I had was to do with the effect of having access to role models in science. Many parents in my interviews mentioned the lack of science-related role models in their children's lives in the UK, and explained why they thought this was a key barrier for their science aspirations.

In order to examine the relationship between role models in science and aspirations in science, I first created three categories of students (high role model visibility, medium role model visibility, low role model visibility), according to the number of individuals they reported to know in science-related jobs. The three categories were the result of the distribution of role model scores with natural cut-off values. In this classification, 25% of students have high role model visibility, 41% have medium role model visibility, and 34% have low role model visibility. When I examined average science aspiration scores in these three groups, I found that they significantly vary (at the 0.05 level) across the three groups (one-way ANOVA with $F=4.611$, $p=0.013$) with the low role model visibility group having the lowest aspirations in science (mean score=2.360) compared to the medium role model visibility group (mean score=3.111) and the high role model visibility group (mean score=3.00). This finding supports my earlier interview results on the association between role models and science aspirations.

Finally, I investigated the relationship between parental science attitudes and students' science aspirations. This was another key theme that emerged from the interviews. In order to investigate this relationship, I compared parental science attitude scores in four different science aspiration levels using a one-way ANOVA test. I found significant differences in average parental science attitude scores of the different groups ($F=6.903$, $p=0.00$) with the high aspiration group having a mean parental attitude score of 4.309, the medium aspiration group having one of 4.17, the low aspiration group having one of 3.88 and the very low aspiration group having a mean parental aspiration score of 3.41. this indicates that the higher the aspiration level of a student, the higher his/her parental science attitudes, which supports the related findings from my interviews.

7.5. Resources, capability and functioning development: Independent school vs maintained school

As mentioned earlier, my data collection efforts in the UK involved Turkish immigrant children from two schools in London. These two schools were quite different in nature with one being an independent school and the other maintained school.

Indeed, not only schools, but also corresponding parent profiles and even teacher experiences could be quite different in these schools, as suggested by Mr Harris, a science teacher at the independent Athenaeum School:

> I think that teacher-parent relationship is very positive at Athenaeum school and parents are very supportive. I am very appreciative of their support. I think overall at this school parent support is outstanding. With compare to some of the schools I worked, it is certainly a lot more positive. I have spent more than 10 years in the state sector, and I had incidents where parents coming and verbally attacking me, physically attacking me, there have been incidents where police have been contacted, you don't get that support. There were sometimes battles on what I teach them and what the parents think I should be teaching them. When I came here it is the opposite. It is "whatever you say, Mr Harris it is fine, if Mr Harris says that's OK". It is very supportive, because parents are paying for their children to come here, and they want the child to learn. And the children will learn because the teacher has that support from the parents, so it is just a win-win relationship.

As outlined in Chapter 4, Athenaeum School is a Turkish independent school which is a non-denominational and co-educational day school. The school has a total of 82 students, and 12 teachers. Annual school fee at the time of data collection was £6,750. In the most recent OFSTED inspection, the school was identified as a 'Good' school with inspectors commenting: "The quality of teaching and assessment is good, and pupils make good progress. Pupils' spiritual, moral, social and cultural development is outstanding due to the school's emphasis on this aspect of its work and the family-like ethos of the school".

ANS, on the other hand is a large than average-sized secondary (maintained) school established in 1982 in London. This school has a higher than average proportion of students supported by pupil premium (i.e., additional government funding to support particular groups of students, such as those known to be eligible for free school meals and those looked after by the local authority). The proportion of students from minority ethnic backgrounds is also well above the national average at the ANS School. In the most recent OFSTED inspection, ANS was also identified as a ‘Good’ school with inspectors highlighting: “Achievement is good and rising. The vast majority of students make at least the nationally expected rate of progress. Staff are exceptionally successful in creating harmonious relationships with all students. Students have positive attitudes to learning. They say they feel very safe in school, are proud of their school and are very well cared for. Parents overwhelmingly support this view.”

Of the 93 Turkish immigrant students who participated in my survey, 51 (55%) of them were from the Athenaeum School and 42 students (45%) were from the ANS School. Because these two schools differ significantly in terms of fees (ANS is free, Athenaeum is not), school size (ANS large, Athenaeum small), and student population (ANS is mixed with a significant Turkish student body, Athenaeum is almost entirely Turkish), these may have implications for students’ science-related capability and functioning development. I therefore investigate differences between the two groups of students (Athenaeum versus ANS) in terms of initial resources they are provided with, their science-related capabilities, and science-related functionings.

I first examined the two groups in terms of their initial resources. According to one-way ANOVA test, both fathers’ and mothers’ educational levels were significantly higher for the students from Athenaeum school with compare to students from the ANS school ($p=0.000$ and $p=0.022$ respectively). Also, while there was no statistically significant difference in two groups in terms of mothers’ English language levels, Athenaeum students’ fathers have higher English skills than ANS students’ fathers ($p=0.000$). In addition, although parents in Athenaeum are less likely to live in council provided housing ($p=0.000$), there was no significant difference between the two groups in terms of their neighbourhood’s deprivation indexes ($p=0.323$). Furthermore, students from the two schools have similar ethnic self-concepts and they also do not significantly differ in terms of how long parents have been living in the UK. I also examined parental science attitudes in the two groups. Parents of the Athenaeum students have more positive science attitudes with an average score of 4.02 than parents at the ANS school (average score=3.58) which was a statistically significant difference (p=0.011) in a one-way ANOVA test.

These findings suggest that students in the Athenaeum school and in the ANS school somewhat differ in the initial resources they are provided with. Athenaeum students appear to have access to greater resources with parents having higher educational levels, fathers with better English skills and parents overall with more positive science attitudes.

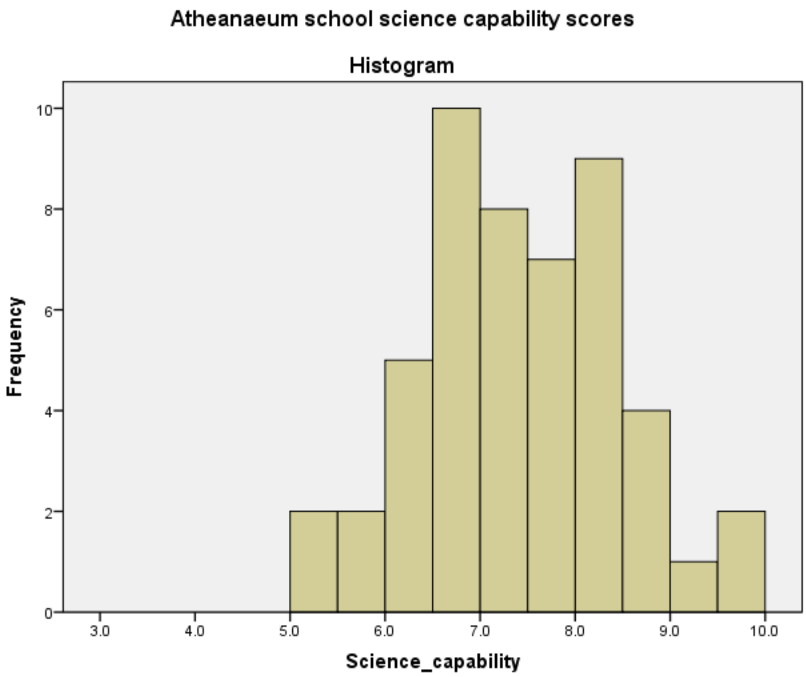
I next explore whether students in the two schools differ in their science capabilities and associated conversion mechanisms. In order to examine this, I first compared the two groups in terms of students' average science capabilities. I found that students at the Athenaeum School have an average capability score of 7.36 whereas students at the ANS schools have an average capability score of 6.61, and this difference was significant (p=0.006) according to a one-way ANOVA test.

As I observe this difference between the two schools in terms of students' science-related capabilities, according my theoretical model, this can be due to several reasons. This difference can be attributed entirely to the differences in students' initial resources if the conversion factors are similar for all students regardless of their school. On the other hand, in addition to initial resources, students in the two schools may also have quite different conversion factors such as different levels of parental involvement, parental science activity, and cultural practices. In addition, being in different types of schools (fee-paying vs maintained) their 'field' of education is also different which may provide significantly different in-school experiences to students.

I therefore investigate these factors in more detail. I first focus actual school differences. Recall that in my survey, I had a question asking students' attitudes towards school science. When I compared students' responses in the two schools, Athenaeum students had much higher positive attitudes towards school science (score= 3.712) than ANS students (score=3.011) with p=0.001. There was also one question in my survey asking about peer attitude, that is, students' classmates' attitudes to science. Athenaeum students scored higher than ANS students (3.100 vs 2.486) which was again statistically significant (p=0.001) in a one-way ANOVA test. These findings suggest that there may indeed be differences between the two schools in terms of in-school factors for science capability development. However, without further studies, it is not possible to identify specific factors or differences between the two schools in terms of science education practices. Despite being different types, both schools are rated “Good” in the most recent inspections, and also my observations and interviews to science teachers in both schools indicated that both have highly motivated and competent staff members in science. In addition, although ANS is a larger school and has a much more diverse student profile with students from many ethnic origins, parental access and involvement was not a major issue as the school has a Turkish students’ liaison offices, a full-time staff member dedicated to this post, who is of Turkish origin. He had extensive teaching experience and can communicate to parents in Turkish. Indeed, according to my survey results, parental involvement at ANS was at very similar levels with compare to Athenaeum and there was no statistically significant differences between the two. Because the focus of my thesis is about outside-school factors in science capability development, I did not further investigate in-school dynamics and how these may differ between the two schools, which may then potentially effect science-related capability development. However, I believe this can be an interesting future research direction.

In examining other conversion factors in students’ science-related capability development and whether these differ significantly between the two schools, I found that although students in both schools have similar levels of interest in outside-school science activities (i.e., there is no statistically significant difference between the two groups with p=0.216); parents at Athenaeum school take part in greater number of science-related activities with their children with compare to ANS parents (score=2.55 vs 1.75 with p=0.012). Also, students in both schools have very similar scores in their cultural activities (p=0.458). Finally, when I look at science-related functioning in terms of students’ science aspirations, I again see a statistically significant difference with Athenaeum students having higher science aspirations than ANS students (score=3.168 vs 2.400, p=0.001). Also, consistent with my previous findings, I found that the schools’ students also differ significantly in their role model visibility with Athenaeum students having a role mode score twice as much as ANS students (role model score=5.37 vs 2.81, p=0.000).

Overall, considering my findings so far in science-related capability and functioning development in two schools, Athenaeum students appear to have greater initial resources to begin with as compared to ANS students. In addition, some conversion factors such as parental activities appear to take place in greater amounts for Athenaeum students. Taken together, these lead to, on average, higher science-related capability and functioning development for Athenaeum students than ANS schools. This, however, does not suggest that fee paying Athenaeum students always have greater science capabilities or functionings than regular maintained school students at ANS. This also does not contradict with my model which highlights the positive and active role of agency and capability development with compare to detrimental effects of structural limitations. In fact, as can be seen in the distribution of science-related capability scores in the two schools (Figure 7.6 below), there are students with very high science capabilities in both schools. The main difference between the two schools appears to be that, in Athenaeum school there are almost no students with very low science capability scores. This could be attributed to in-school factors at Athenaeum such as small schools size and higher personalised attention to students and parents. In addition, this may also be linked to differences between families or school-family interactions where the independent school may demand and facilitate more active parental relationships.



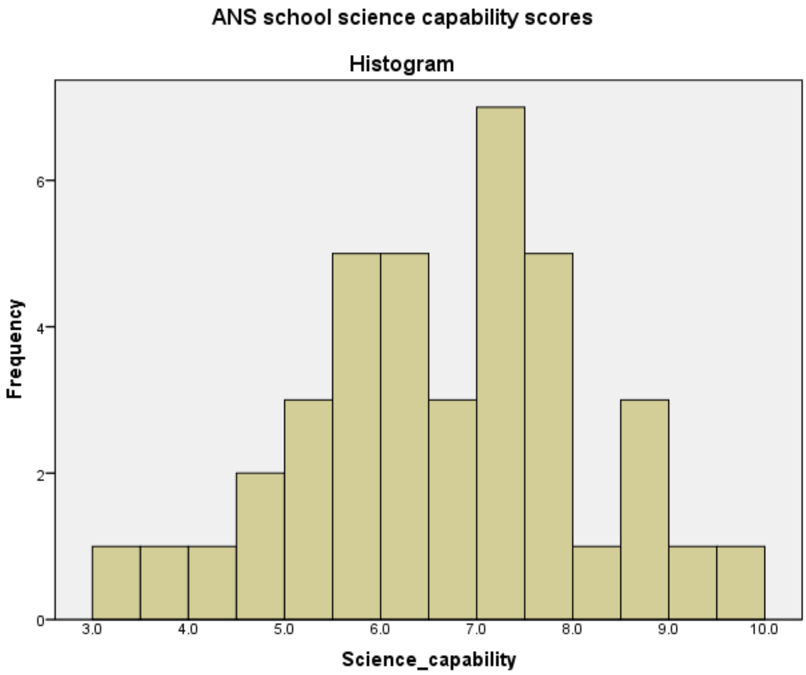


Figure 7.6 Science capability scores at Athenaeum and ANS school

7.6. Discussion

Informed by my theoretical model in Chapter 3, and following the structure of Chapter 6, in this chapter I first present my survey results on initial science-related resources, and then consider how science-related capabilities and functionings are developed.

I found that Turkish minority students are well aware of their ethnic identity. My results also indicated that this identity is generated first at home, and then regenerated through interactions within the family, with mostly Turkish friends, and through social and cultural practices. Easy and continues access to Turkish TV channels also appeared to have a significant role in this identification process. Indeed, research on immigrants indicate that immigrants are increasingly able to preserve relationships and cultural identities associated with their home country (Schiller et al., 1992; Kivisto, 2001; Vertovec, 2001) through instruments such as satellite TV (Aksoy & Robins, 1997; Becker, 1996).

Supporting the theoretical model, most students did not feel that their ethnic background generates structural limitations to act as a barrier to what they can achieve in science. Similarly, family socio-economic status as proxied by students' home status (council house, rent, own) and parents' educational background appears to have quite a limited effect on students' science outcomes, which is also consistent with the interview findings. Indeed, both the qualitative and the quantitative findings seem to be in accord with existing research which has highlighted the potentially limited role of SES on students' educational outcomes (Jencks et al., 1972; Sui-Chu & Willms, 1996).

My next goal with the survey was to identify potentially significant conversion factors that are associated with science capabilities. However, a critical issue in my survey design was the measurement of science capabilities. For that, I used a blend of original questions I prepared, based on my theoretical framework, with a focus on 'the ability to achieve' science rather than the outcome in science (Sen, 1993; 1999), and a set of self-concept questions in science based on existing studies (Oliver & Simpson 1988; Beghetto, 2007).

My survey analysis indicated several conversion factors that have significant association with students' science capabilities, such as parental involvement in general, high parental science-related activity and parents' English language skills.

An interesting finding that was not in agreement with the qualitative analysis was that a notable portion of students thought that their parents do not find science interesting and also they did not believe their parents would be happy if they became a scientist one day. These findings suggest that parents may not be as enthusiastic about science in their children's presence as they appeared to be during my interviews with them; it may be children do not know about or strongly feel about their parents' positive science attitudes because they are not communicated to them or not translated into actions by their parents. I also explored the attitude-activity gap I identified in Chapter 6, and found that students who have positive parental attitudes accompanied by high parental activity have the highest science capability scores. This finding again highlights the role of agency in potentially mitigating structural limitations associated with Turkish immigrant parents. Although minority immigrant parents face and perceive barriers to their involvement (Carreon, Drake & Barton, 2005; Turney & Kato, 2009), at the same time, children of immigrant parents can greatly benefit from parental involvement and practices (Kao, 2004; Kim, 2002).

While my empirical results highlight parental involvement and parental activities as critical conversion factors in Turkish minority students' science-related capability development, I do not suggest that access, inclusion and equity issues, discussed in depth by Bourdieu (1977; 1986; 1993), would disappear with such parental practice. My point is that parental involvement and activities do vary independent of the structural characteristics of families (Sui-Chu & Willms, 1996; Jimerson et al., 1999; Goldenberg, 2001; Stoep et al., 2002), and this can potentially explain students' science-related capability development even in the presence of very limited initial resources. Also, because Bourdieu's family is mostly functional and static (Silva, 2005), Sen's capability approach (1985; 1992) brings the agency perspective to such parental practices in developing students' science capabilities.

Another critical that was identified in my analysis in Chapter 6 was where students live, their neighbourhood 'field'. In order to further explore the role of neighbourhood in developing Turkish minority students' science capabilities empirically, I made use of the Department for Communities and Local Government's indices of deprivation (2015) database by linking them with students' postal codes which I collected in my survey. My analysis found no statistical association between students' neighbourhoods and their science capabilities. In addition, a notable percentage of high science capability students in my sample (30%) were found to live in highly deprived neighbourhoods, suggesting that despite structural limitations such as living in a highly deprived area, students can still develop high science capabilities. This finding appears to confirm my theoretical model which argued that students' science capabilities are not predominantly driven by just structural factors such as their socio-economic status (initial capital) or their neighbourhood (field); rather, agency (Sen, 1992) can play a significant role in developing science capabilities. In addition, my findings indicated that students' cultural and ethnic self-concept (e.g., taking part in cultural practices related to background such as food, dance, music, customs; having a clear sense of ethnic background etc.) seemed to be conducive for capability development. Finally, findings in this chapter with regards to science functioning development were consistent with results in Chapter 6 where having access to role models was suggested to be an important conversion factor in functioning development.

8 Chapter Eight: Developing science capabilities and functionings: A comparative analysis of Turkish children in the UK vs in Turkey

8.1 Introduction

While the focus of my thesis is Turkish immigrant children in the UK, in order to provide deeper insights into my research questions about their development of science capabilities and functionings, I also conducted an additional piece of work. Specifically, I carried out a similar survey in Turkey and then compared my survey results from the UK and from Turkey. The goal of this analysis is to better understand the role of being immigrant in students' science-related capability and functioning development. To what extent Turkish immigrant children in the UK are different or similar to those children in Turkey in terms of their science attitudes, initial resources, and their respective science-related capabilities and functionings are important follow-up questions to my existing findings. In addition, especially during my interviews (see Chapter 6), many Turkish parents provided detailed and vivid comparisons between their lives in the UK and their relatives and friends' lives in Turkey. With regards to this, they also highlighted potential advantages and disadvantages of their children in science capability development compared to their counterparts in Turkey. Considering these points, in this chapter I explore similarities and differences between Turkish students' science attitudes and aspirations, and their capability and functioning development in the UK versus in Turkey.

Part of the rationale for this comparative analysis is that, in relation to science, Turkish children in the UK and their immigrant parents could be sharing many similar dispositions, values, cultural discourses and identifications, what Archer et al. (2012) call 'family habitus', with their counterparts in Turkey. Considering such shared similarities, once the difference between the two education systems and in-school factors in the UK and in Turkey are taken into account, then the remaining differences between students' science-related capabilities and functionings could be partly explained by the immigrant identity and experience. Indeed, Fitzgerald (2006;

2012) recommended this approach in immigrant studies where he compares migrants who moved internationally to the people who stayed in the place of origin.

A total of 383 students from five schools in Istanbul participated in my survey in Turkey, compared to 93 students in London, UK. Similar to the UK, I tried to have a mix of maintained schools and independent schools in Turkey, so out of the five schools, two were independent schools and three were maintained schools. The ratio of female:male students who participated in my survey in Turkey was 61% male and 39% female students (exactly the same as in the UK). Among the participants in Turkey, 20% were Year 7 students, 33% were Year 8 students, 39% were Year 9 and 8% were Year 10 students (these percentages in the UK were 26%, 13%, 17%, and 44% respectively).

In order for my Turkish survey to be comparable with the one I conducted in London, I collected data only from Istanbul, the largest city in Turkey with the greatest share of economic activity. There is also significant internal migration in Turkey with cities like Istanbul attracting significant new people each year. In fact, among the students who participated in my survey, 24% were not born in Istanbul.

In comparing my survey results in the UK and in Turkey, I primarily used a one-way ANOVA test to check if there are statistically significant difference between the means of the two groups (UK and Turkey) in terms of the variables I examine. In order to use one-way ANOVA, I first checked whether the distribution of my dependent variables (e.g., science attitudes, science aspirations, science capability scores, etc.) is approximately normal. Indeed, for most of the cases normality assumptions were satisfied, so I used one-way ANOVA. In the few cases where the normality assumption was not satisfied, instead of one-way ANOVA, I used the non-parametric Kruskal-Wallis test.

Another important assumption of the one-way ANOVA test is homogeneity of variance. In part because my sample size for the survey in the UK and in Turkey was quite different, with 93 participants in the UK and 383 participants in Turkey, a potential risk is that the homogeneity of variance assumption could be violated. In all my analyses, I therefore checked for the homogeneity of variances using Levene's test. While homogeneity of variance was confirmed in most analyses, the variance was found to be not homogenous in several cases. In these cases, I used the alternative Welch ANOVA test to check and confirm my one-way ANOVA results.

8.2 Initial science-related resources

Among the participants in Turkey, 37% of mothers were primary school graduates, 22% graduated from secondary school, 25% from high school and 16% from university or studied at the postgraduate level. The corresponding figures were slightly higher for fathers with 22% with only a primary school education, 24% only a secondary school education, 29% only a high school education, and 25% having a university or postgraduate degree. Overall, compared to the parents in the UK, the parents in Turkey appear to have slightly lower average educational levels (for mothers average score in Turkey 2.21 vs 2.49 in the UK, for fathers 2.60 vs 2.93), and the differences between the two were statistically significant ($p=0.046$ and $p=0.023$ respectively) in a one-way ANOVA test.

In the UK 61% of the students reported that their mothers are either housewives or unemployed (Section 7.1). This figure is even higher for the students in Turkey with 76% of students reporting that their mothers are housewives or not employed, and this difference is statistically significant according to a one-way ANOVA test ($p<0.05$).

When students in Turkey were probed about their parents' science interests, 50% of them stated that their parents think science is interesting, 33% were neutral and 17% indicated that their parents do not find science interesting. Parents' science interests were reported as being somewhat higher for students in the UK with 66%, 23% and 11% respectively. In addition, 62% of students in Turkey responded that their parents would be happy if they became a scientist when they grow up (a similar figure of 58% of UK students reported this). When it gets to their parents' thoughts on the importance of science, a large majority of the students in Turkey (71%) indicated that their parents think it is important for them to learn science with compare to 78% of students in the UK. Similar to the case I observed in the UK in Chapter 7, I also see a difference between Turkey students' responses to the statement ‘my parents/carers think science is interesting’ (50%) and ‘my parents/carers think it is important for me to learn science’ (71%). This suggests that both in the UK and in Turkey, there is quite a large group of parents who do not find science interesting, but nevertheless think that it is important for their children to learn science.

Overall, when I compared average parental science attitudes in the UK vs in Turkey, I found that parents in the UK are reported as having slightly higher science attitudes with an average score of 3.84 (compared to 3.76 in Turkey), but the difference is not statistically significant ($p>0.05$) with a one-way ANOVA test.

I next explore the development of science capabilities for students in the two countries.

8.3 Developing science capabilities

I first compared average science capability scores between Turkish immigrant students in the UK and students in Turkey. Interestingly, students in Turkey appear to have higher science capabilities with an average score of 7.46 whereas students in the UK have an average score of 7.03. This difference approaches statistical significant ($F=3.184$, $p=0.075$, one-way ANOVA). This finding is interesting because compared to students in Turkey, Turkish immigrant students in the UK appear to have slightly higher initial resources with their parents having higher educational backgrounds and also parents demonstrating more positive attitudes towards science (Section 8.1). But, despite this relatively more advantageous position, Turkish immigrant students in the UK exhibit, if anything, lower levels of science capabilities than students in Turkey. Why is this the case? In the remainder of this section, I will try to address this question.

According to my theoretical model, students are first provided with initial resources and then through a variety of conversion factors, such as parental involvement, parental activities, attitudes or the field in which the students are situated, they develop science capabilities. The fact that, despite having somewhat higher resources, students in the UK possibly show lower science capabilities suggests that there may be significant differences in terms of the conversion factors in the UK versus in Turkey. Specifically, some conversion factors may be more prevalent for students in Turkey; alternatively, some conversion factors may be quite rare or less significant for Turkish immigrant students in the UK. Consequently, I examined potential conversion factors to see whether their mean scores are statistically significantly different between the two groups (i.e., Turkey vs UK).

Parental involvement. The first conversion factor I examined is the general parental involvement. This includes responses to questions such as parents attending parents' evenings, helping students with homework or asking detailed questions about school lessons. According to the one-way ANOVA test, there was no statistically significant difference (p=0.207) between students in Turkey and in the UK in terms of their parental involvement. However, because Levene's test indicated that the assumption of homogeneity of variance is violated (Levene statistic=5.19, p=0.02) for parental involvement scores in a one-way ANOVA, I also ran a Welch ANOVA test. The results of the Welch ANOVA test again indicated that there is no statistically significant difference between the UK and Turkey (p=0.157) in parental involvement.

Parental aspirations. In terms of parental aspirations, I found no significant difference between Turkish immigrant students in the UK and students in Turkey (F=1.23, p=0.518). In both groups, general parental aspirations (e.g., wanting their children to go to university) were quite high.

Interest in outside-school science activity. One notable finding is that students in Turkey appear to have greater interest in outside-school science activity (mean score=3.55) compared to Turkish immigrant students in the UK (mean score=3.27) (F=7.17, p=0.008). While there may be multiple reasons for this, one possible explanation could be due to the relatively limited availability of science museums, science parks or outdoor activity spaces in Istanbul, which may result in students in Turkey demonstrating greater interest in such activities. Greater interest in outside-school science activities could be one of the drivers (i.e., conversion factors) for increased science capabilities for students in Turkey.

Parental science activity. Students in Turkey on average have slightly higher scores of outside-school science activity with their parents (average score=2.92) compared to immigrant Turkish students in the UK (average score=2.61), and this difference approaches statistical significance (F=2.04, p=0.10). There may be relatively more opportunities for science-related activities in the UK with more science museums, parks or science fairs, but on the other hand, Turkish immigrant parents in the UK may experience greater limitations on availability and time, resulting in lower parental science activities. In fact, a common theme that was highlighted in my interviews with Turkish immigrant parents in the UK in Chapter 6 was the long working hours of many Turkish parents which leave little time to spend together with their children. Similarly, many Turkish immigrant parents in my interviews indicated how a large family in Turkey could be very useful, especially in raising small children with available grandparents or close relatives providing critical help and support[7]. Such support could provide additional flexibility for parents in Turkey, enabling them to spend more time in science-related activities with their school-age children.

Another potential explanation could be that, despite the availability of many science-related activity resources in the UK, Turkish immigrant parents may not feel particularly comfortable or welcome in such environments and get a ‘not for us’ feeling (Dawson, 2014). For example, limited English language skills of many parents may lead to a feeling of exclusion or discomfort during such visits in the UK. However, in Turkey, even if there may be limited opportunities or resources for informal science learning environments, parents are likely to feel more comfortable, more ‘at home’ in such places. This may in turn lead to better and more effective learning opportunities for both parents and children in Turkey.

Cultural activity. Cultural activities, actions and dispositions could play an important role in supporting students’ science-related capability development. As outlined in Section 7.3.7, I created a new composite measure for *cultural activity*, based on (i) *the number of times the student visited a museum, historical site or art*

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[7] As a Turkish mother of two children born while I undertook my PhD in England, I very much agree with these statements.

gallery in the past 12 months, (ii) *the number of times the student attended a play, concert or a live show in the past 12 months,* (iii) *the number of hours the student spend in a week in cultural lessons/activities outside of school (music, art, dance, language, etc)* and (iv) *the number of hours the student spend in a week reading a book.* I then compared Turkish immigrant students in the UK and Turkish students in Turkey in terms of their average cultural activity. Perhaps surprisingly, students in Turkey have higher average cultural activity scores (score=4.39) compared to immigrant students in the UK (score=3.70) (F=5.33, p=0.02).

Attitude towards school science. Because the focus of my study is on outside-school factors, it is important to also check for the potential role of in-school factors on students' capability development. There are clearly many differences between the UK and Turkey in terms of science education and school science, and an in-depth exploration of this is outside the scope of this study. However, I can still gain useful information by comparing and contrasting students' attitudes towards school science in the UK vs in Turkey. If there are major differences in students' attitudes to school science in the two countries, then different science-related capability levels of UK vs Turkey students could be partially explained by the in-school factors. If, on the other hand, there is not much difference in students' attitudes towards school science in the two countries, then I can be more confident about the significant role of outside-school elements and associated conversion factors in driving science capabilities. The one-way ANOVA test shows that there is no statistically significant difference between the UK and Turkey students in terms of their attitudes to school science (p=0.618).

8.4 Developing science functionings

In the previous section, I noted that despite having more limited initial resources, students in Turkey demonstrated somewhat higher science capabilities compared to their counterpart Turkish immigrant students in the UK. I then suggested that certain conversion factors from initial resources to science capabilities may be at play so that students in the two countries differ in their developed science capabilities.

In this section, I focus on science functionings, and explore whether and to what extent students' science functionings differ in Turkey and the UK. I then explore the potential role of a second set of conversion factors, this time from science-related capabilities to science-related functionings, as outlined in my theoretical model.

Following Section 7.4, I primarily focus on students' science aspirations as an important outcome related to science functionings.

When I compared students' science aspirations, an indicator for functionings, I found that students in Turkey have significantly higher science aspirations (average score=3.09) than Turkish students in the UK (average score=2.83) (F=4.313, p=0.038). Furthermore, while the difference in science capabilities between students in Turkey and in the UK was not quite statistically significant (p=0.075), difference in functionings between the two countries are statistically significant at the 5% level. I therefore suggest that if the first set of conversion factors leads to differential science capability development in the two countries, despite comparable initial resources, the second set of conversion factors increases this gap, leading to differential science functioning development in the two countries. Which conversion factors may then play a role in science-related functioning development? I explore this next.

Role models. In my interviews in Chapter 6, many parents mentioned the lack of science-related role models in their children's lives in the UK. Most of these parents then contrasted this situation with the one in Turkey where they say children have greater and easier access to role models in science. In order to examine this, I first developed a role mode score for each student based on the number of individuals they reported knowing in science-related jobs. I then compared average role model scores of students in Turkey and students in the UK. Consistent with my interview results, I found that students in Turkey have a role model access that is almost statistically significantly greater than students in the UK (average score=4.86 vs 4.22) according a one-way ANOVA test (p=0.058).

In my theoretical model, I highlighted the potential importance of role models in converting students' science capabilities to science functionings. Here, a suitable explanation for my finding of higher science functionings for students in Turkey (compared to students in the UK) could be that students in Turkey have greater access to science-related role models. Through this access, they can more easily convert their already higher science capabilities to science functionings.

Positive image of scientists. Students' images of scientists could be another potential conversion factor leading to increased or decreased aspirations in science. In order to examine the potential role of a positive image of scientists, I first used students' answers to three questions in the survey to calculate a positive image of scientist score. For this, I used their average response to the items: 'Scientists and people who work in science can make a difference in the world', 'Scientists have exciting jobs' and 'Scientists are respected by other people'. When I compared Turkey and UK in terms of students' positive image of scientists, I found a highly significant difference between the two. Specifically, students in Turkey have much more positive images of scientists compared to Turkish immigrant students in the UK ($F=15.92$, $p=0.000$). This may contribute to students in Turkey possessing greater science functionings,

Stereotypical image of scientists. As opposed to positive images of scientists, stereotypical images of scientists could potentially inhibit the development of science functionings. I therefore examined students' answer to one question in the survey: 'Scientists can't be religious'. Students in Turkey were more significantly more likely to disagree with this statement than their UK counterparts ($p=0.01$).

Overall, my findings on science functionings in Turkey and in the UK suggest that students in Turkey exhibit greater science functionings, and such greater science functionings are driven, at least in part, by greater access to role models, more positive image of scientists and less stereotypical image of scientists.

8.5 Discussion

While the attention of the thesis was on Turkish minority children in the UK, in order to better understand outside-school factors related to being children of Turkish immigrant parents, I conducted a comparative analysis between students who were in Turkey and Turkish minority students in the UK. This analysis helped address my last research question: "How are immigrant Turkish students in the UK similar or different in their science capability and functioning development compared to their counterparts in Turkey?".

The analysis primarily involved comparing the two groups of students in Turkey and in the UK in light of the theoretical model with a focus on their initial science-related resources, capabilities and functionings, and corresponding conversion factors. Because of the limited sample sizes, the students' and schools' representative limitations of the corresponding countries, many differences between the education systems and the practices and dispositions about science in the two countries, this work should be considered as an initial exploratory study, and results should be interpreted accordingly. However, despite these, findings in this section could provide additional perspective and enrich our understanding of Turkish immigration children in the UK and their science attitudes.

The results indicated that while students in Turkey were endowed with somewhat lower initial resources than Turkish immigrant students in the UK, surprisingly it appears that students in Turkey tended to have relatively higher science-related capabilities than their Turkish minority counterparts in the UK. In addition, students in Turkey appear to demonstrate even greater science functionings in comparison to Turkish minority students in the UK which can be partly explained by having greater and more personal access to science-related role models in Turkey and having much more positive images of scientists compared to Turkish immigrant students in the UK.

Interestingly, according to many international comparisons, Turkey's science education appears to be mediocre at best with a ranking of 54th and a below average score in the most recent PISA study (OECD, 2016). Also, in a cross-national study of secondary school students' science learning and science attitudes (i.e., the Relevance of Science Education) project with more than 40 countries, Turkey was ranked below average (Sjoberg & Schreiner, 2006). Indeed, concerns about science education in Turkey such as large class sizes, an overloaded curriculum, inadequate teacher training, too much emphasis on delivery of information and lecturing and very limited experiment/lab opportunities have been extensively noted (Ozden, 2007). Also, one can argue that students and parents in the UK have many more opportunities to be involved with and to engage with science centres, museums or parks. However, despite all these seeming advantages in the UK, it appears that on average immigrant Turkish children in the UK have lower science capabilities and science functionings than their counterparts in Turkey. These results highlight potentially substantial disadvantages faced by immigrant Turkish children who seem to be doing worse than students in Turkey in terms of science capability and functioning development despite all the opportunities and resources that are available to them.

9 Chapter Nine: Discussion

9.1 Introduction

This chapter brings together the primary findings of the thesis and discusses its contribution to knowledge in science education. My thesis has investigated the role of outside-school factors in students' formation and expansion of science capabilities in the context of Turkish minority students living in London. Outside-school factors such as parents, the extended family, friends, cultural values and daily activities and practices have long been thought to play a major role in influencing students' science participation (Crowley et al., 2001; Dabney et al., 2013; Dierking & Falk, 1994). Because a substantial portion of students' science attitudes and inspirations develop within the context of their families, their cultural background and their daily lives (Osborne, 2007), and out-of-school experiences provide students with opportunities to construct, modify and reflect on the knowledge they gain in the classroom (Tran, 2011), it is important to pay close attention to outside-school factors in understanding students' formation and expansion of science capabilities.

In addition, students from minority ethnic groups face unique challenges in their science participation where aforementioned outside-school factors have been suggested to play a major role (Archer et al., 2015; Jones & Elias 2005; Turney & Kato, 2009).

I addressed four related questions in my thesis. The first question examined "How can we explain patterns of science participation of Turkish minority students?" In addressing this question, I developed a new theoretical model explaining students patterns of science participation in Chapter 3 linking Bourdieu's key concepts of habitus, cultural and social capital, and field with Sen's capability approach. I then illustrated and tested the theoretical model with a case study in Chapter 5.

My second and third research questions focused on identifying specific outside-school factors: "How do cultural contexts and parental attitudes, involvement and practices influence immigrant Turkish students' formation and expansion of science capabilities?" and "What other outside-school factors promote or inhibit immigrant

Turkish students' attitudes and aspiration in science and how?". I addressed these two research questions first with an interview-based qualitative study in Chapter 6 and then via a survey-based quantitative study in Chapter 7. Finally, in order to gain further insights on the role of being immigrant in students' formation and expansion of science capabilities, I explored "How are immigrant Turkish students similar or different in their science capability and functioning development compared to their counterparts in Turkey?" in Chapter 8.

As discussed in Chapter 4, I used a mixed-methods approach to address my research questions. The main research methods in the thesis were semi-structured interviews and student surveys. Interviews were conducted with students (n=16), parents (n=11) and teachers and staff (n=7) at two schools in London: one independent Turkish school and one maintained school with a large Turkish student population. Surveys were conducted with Turkish students in the aforementioned two schools (n=93) as well as in five additional schools in Istanbul, Turkey (n=383). In addition, to facilitate my contextual understanding and to help with data collection, interpretation and analyses, I made a total of 20 hours of in-class observation of science lessons in the two schools in London and in the five schools in Istanbul. Considering my research aims, I analysed the data in light of the sociologically informed theoretical framework developed in Chapter 3.

I provide an overview of the thesis findings and contributions in Section 9.2.

9.2 Summary of research findings and contributions to knowledge

This study provides contributions to knowledge on two fronts. First, the thesis provides new data and analysis into Turkish minority students' development of science attitudes and aspirations. Despite the growing concern and corresponding research interest in the UK on ethnic minority students' science participation, most studies in this area, whether quantitative and qualitative, have focused on 'major' minority ethnic groups such as British Black African/Caribbean, Pakistani, Bangladeshi, Indian or Chinese students, and paid limited attention to other groups. Yet, other minority ethnic groups represent a notable portion of today's British society, with each minority group having certain unique characteristics with also varying attitudes and participation rates in science (Elias & Jones, 2006). My study helps to fill this gap by focusing on the Turkish-speaking community in the UK which involves mainland Turks, Kurdish Turks and Cypriot Turks with a large population of between 250,000 (Düvell, 2010) and half a million (Travis, 2011) people. The findings of this study provide empirical data that suggest a new way of understanding Turkish minority students' development of science capabilities and functionings. Through analysis of interview and survey data, the study identifies a set of resources and conversion factors that influence Turkish minority students' science-related capability and functioning development.

Secondly, the study makes a conceptual contribution to science education literature by combining Bourdieusian theory and Sen's capability approach. Indeed. the first research question in the thesis explores how to explain patterns of science participation of Turkish minority students. The thesis addresses this question by presenting a new theoretical model that integrates Bourdieu and Sen in explaining students' science participation, as summarised below.

9.2.1 Integrating Bourdieu and Sen for science participation: A new theoretical model

From home environment and parents' socio-economic background to cultural contexts, and from role models in the family to everyday parent-child activity, the literature in science education has suggested and documented the influence of outside-school factors in students' formation of science attitudes and aspirations, and their attainment in science classes. However, part of this literature is fragmented as each study examines only a small number of relationships. While establishing these relationships is important, I suggest that a broader theoretical framework is needed to help us understand the role of outside-school factors in science education, and the mechanisms through which these factors influence students' participation in science.

A key theoretical contribution of this study is therefore the development of a novel theoretical model by making use of and integrating the two frameworks of Bourdieu (1977; 1993) and Sen (1992; 1993). Through this model, I explained how outside-school factors can act both as an initial resource provider and then as a converter in students' development of science-related capabilities. Although these frameworks have been used extensively by education researchers, their use has been relatively limited in science education. A small number of studies in science education have employed Bourdieu's habitus, capital and field (notably, Adamuti-Trache & Andres, 2008; Archer et al., 2012 and related publications; Brandt et al., 2010; Dimick, 2015; Wong, 2012). I believe my study is the first one that uses Sen's capability approach in science education.

Using Bourdieu's key concepts of habitus, capital and field, I argued that the first role of outside-school factors is in providing an initial science-related resource set to students. While a Bourdieuian perspective is very useful for explaining students' science-related, outside-school resources and potential reproduction of inequalities in accessing these resources, key concepts of Bourdieu remain focused on social reproduction rather than social change (Calhoun et al., 1993) and pre-reflective features of action (Reay, 2004; Sayer, 2004). As such, their use in understanding how outside-school factors may change science-related decisions and aspirations may be limited.

After all, structure plays an important role in habitus and field, as habitus "is a socialised, structured body", and field "structures the perception of the world as well as action in that world" (Bourdieu, 1998a, p.81). This structure and system of dispositions provide a certain expected way of thinking or acting in certain circumstances, and excludes certain practices and actions (Bourdieu, 1990). However, to gain a deeper understanding of the role of outside-school factors, I wanted to go beyond the structure acquired by the students, or gained dispositions leading to certain way of actions; I sought to also explore agency formation and its consequences related to science.

Sen's capability approach, with its focus on agency and capabilities, provided this complementary framework. As an economic theory in origin, Sen's capability approach does not primarily focus on resources. Instead, he prioritizes capabilities (Sen, 1999). Sen's capability framework helps us distinguish between science-related resources, science capabilities (individuals' abilities to achieve) and science functionings (outcomes achieved by individuals).

Integrating Bourdieu and Sen is not only useful for a better understanding of the role played by outside-school factors in science education; bringing Bourdieu into Sen's capability approach is also enriching by highlighting economic, social and cultural capitals, and their conversion and interactions in various fields. That is, the initial science-related resources and habitus with which a student is endowed are more than an economic commodity; rather, they are a consequence of all science-related social interactions and reproductions in the first place. Because the capability approach largely focuses on individuals, their freedom and choices, and there is not much mention of social structures (Stewart, 2005), the capability approach's reach and significance can be substantially improved by incorporating Bourdieu's emphasis on habitus, cultural and social capital and field.

In summary, drawing on and synthesizing key ideas from Bourdieu and Sen, in Chapter 3, I developed a two-stage model to understand the role of outside-school factors in science education. Using Bourdieu's key concepts of habitus, capital and field, I argued that the first role of outside-school factors is in providing an initial science-related resource set to students. Making use of Sen's framework, I linked the initial set of resources and the field in which these resources are realised to students' developed capabilities and functionings. I also empirically illustrated the key points of the theoretical model with a case study in Chapter 5 involving three Turkish immigrant students.

I believe an important contribution of the thesis is the introduction of this new theoretical framework which may help advance our understanding of formation and expansion of students' science-related capabilities.

In the light of the data and my empirical findings, several questions and tensions are raised with regards to the theoretical model. First, although Sen's capability approach brings an additional change and agency perspective to students' development of science capabilities and functionings in the model, the relationship between resources, capabilities and functionings appears to be much more dynamic in practice as observed in my data. This dynamic nature is not necessarily fully captured in the theoretical model. For example, for some children there appears to be a feedback loop from developed science capabilities to increased science-related resources, and similarly from functionings to capabilities. For instance, in the case of Fulya and Derya, one may argue that their high science capability leads them to be selected and participate in the science Olympiad which in turn triggers their parents to devote additional social and economic resources to such science activities. Although such feedback mechanisms were somewhat indicated with small back arrows in the model in Figure 3.1, these turn out to be hard to specify and investigate empirically in my study. Building on these observations, the model could be revised to incorporate such a dynamic nature of the interplay between resources, capabilities and functionings.

Secondly, the model also appears to be static in that it does not take into account how the magnitude and significance of certain conversion factors or capabilities may increase or decrease over time with children's age. In several interviews, such changing dynamics over time was mentioned by both parents and students when, for example, comparing and contrasting how certain science-related activities and their significance had changed for them over time. Taking this work forward, the model could perhaps be extended by specifically incorporating the changing nature of certain conversion factors to identify the most influential conversion factors for different age groups for science-related capability and functioning development.

Thirdly, as one of the initial steps towards incorporating Sen's capability approach into science education, the model appears to be limited in providing an explicit and comprehensive list of conversion factors, science capabilities and developed science functionings. Although my study identifies several science-related capabilities and functionings, this is by no means a comprehensive list. For example, considering the data limitations, in my quantitative study, I primarily focus on the variable 'students' science aspirations' as an indicator for their science-related functioning. However, there are clearly other and perhaps more appropriate variables for students' science functioning such as chosen careers or studied subjects at the university level, etc. which could be explored with a larger scale, longitudinal study. While the lack of listing a comprehensive set of capabilities or functionings may be a limitation, it may also give additional flexibility to the model. In fact, in his writings Sen never specifies a list of specific capabilities or important functionings, nor does he provide an outline of how to weigh the importance of various capabilities or functionings, which was a limitation for some (Nussbaum, 1988; Sugden, 1993). However, Sen argues quite convincingly that it is this general and flexible nature that provides the distinctive strength of his approach.

Also, in addition to many in-school factors on which I do not focus in my model, there may also be additional outside-school factors than those identified in the current study which can influence capability or functioning development. In addition, conversion factors are not necessarily the same or of the same magnitude for everyone; while some children may be well equipped with certain conversion factors, others may lack these. Considering my earlier discussions, the existence of conversion factors is also likely to depend on social structures which are not fully captured in the two-stage model created in this thesis (Figure 3.1). Future work could extend my model by considering other conversion factors as well as their explicit relationship and interactions with economic, social and cultural capital, habitus and field.

Despite such limitations, my theoretical framework has been particularly useful in illuminating several key points. One benefit of my theoretical model based on Bourdieu's key concepts was to go beyond commonly known factors such as socio-economic status or ethnicity in student's science participation, and provide a more nuanced and deeper picture of the role of parents in providing initial science-related resources and habitus. For example, in the case of Zeki vs Fulya and Derya, the two families, despite being very similar in terms of their cultural backgrounds, ethnic factors and socio-economic, differ significantly in terms of their science attitudes and the conscious and unconscious practices that operate in these families (Bourdieu, 1992), which resulted in each of the three children acquiring and forming a different science-related habitus. While Fulya and Derya have a good 'feel for the game' for science, Zeki seems not to develop such a feel because even a simple conversation in science is not possible in his family with language acting as a further barrier.

Additionally, through the lens of this model, the difference between outcomes (i.e. functionings) and the ability to achieve these outcomes (i.e. capabilities) related to science education and potentially distinct corresponding conversion factors becomes clearer. I discuss in Section 9.3.1 how this distinction could have practical and policy implications for science education.

Overall, I believe my model can be useful for gaining deeper insights into the role of outside-school factors in science education. For example, without the two-stage model, if one looks at the case of Fulya as outlined in Chapter 5, one may only see a typical input and output in an immigrant student from a low socio-economic background who has low aspirations in science. In fact, Fulya has been provided with a strong science-related habitus as a result of parental attitudes, has a good 'feel for the game' for science, and has very well developed science capabilities enhanced by parental actions; however, of her own choice she does not want to pursue a science-related career. Despite its limitations, I believe my model illuminates such nuances in an effective way.

9.2.2 Science-related resources

The second research question in the thesis examined how cultural contexts and parental attitudes, involvement and practices influence immigrant Turkish students' formation and expansion of science capabilities? The thesis addressed this question by systematically analysing interview and survey data through the prism of the newly developed theoretical model. Namely, the thesis identified specific science-related resources available to Turkish minority students, and then both positive and negative conversion factors that are helpful or detrimental in developing their science capabilities in the first stage and then functionings in the second stage. I provide a summary of these findings below.

One of the main goals of this study was to identify critical science-related resources that are available to Turkish students in the UK. In identifying these initial resources, I took guidance from Bourdieu's key concepts of cultural and social capital, and habitus. I pointed out that for children, their parents, family and socio-cultural environment provide an initial habitus and capital related to science which are formed mainly in the family through social relationships, but the parents and children probably do not even know or realise how this actually occurs, as habitus and cultural and social capital operate in less than a conscious manner (Bourdieu, 1990; Farnell, 2000). Findings in Chapter 6 and Chapter 7 demonstrated a two-sided picture on the role of initial science-related resources on Turkish minority students.

My data point to structured constraints faced by Turkish minority students, but at the same time they also reveal the role of agency on how some parents can provide greater science-related resources despite the existence of such constraints.

On the one hand, there were clear structured constraints in students' initial science-related resources. Some of these appear to be direct consequence of being children of immigrant parents, such as limited time availability of immigrant parents with long work hours, lack of family/parental resources to help with children's and parents' limited English ability and limited knowledge about the education system. Also, most of the students came from low to moderate socio-economic backgrounds, with more than 60% of mothers being reported to be either unemployed or housewives, and only 10% of fathers being reported to have professional jobs. Furthermore, some parents had a quite negative attitude towards science by describing it as "hard", "boring", or "distant from real life". In addition to the direct effects of these factors, they also appear to have a major detrimental role in Turkish immigrant children's transmission, accumulation and conversion of various forms of capital as outlined by Bourdieu (1986), which in turn reproduce structured constraints. For example, some parents' positive attitude to science was never transmitted to children because of parents' lack of English skills, which made it hard to have any science-related conversations with their children whose science conception is almost entirely in English. Similarly, some Turkish parents had quite high economic resources, but having a small social circle of mostly Turkish friends and limited knowledge of the education system in the UK, they seemed to be unaware of how such economic capital can be converted into greater social, cultural or science-related capital for their children though private education, tuition, or other means. That is, as Bourdieu (1986) pointed out, various forms of capital can be converted from one to another, and they have exchange value (Skeggs, 2004), but it was not easy for many immigrant parents to realise such exchange potential and act upon it.

On the other hand, my data revealed that the role of agency in overcoming such structured barriers should not be underestimated. It is not only in the possession of capitals that families may differ, but they may also differ in their desire to activate capitals (Vincent et al., 2012). While many families in my data were very similar in terms of their cultural backgrounds, ethnic factors and socio-economic status, some parents were able to provide much greater science-related resources to their children with their positive science attitudes and associated actions. These involve a genuine interest in science independent of their children, their own educational background or occupation. It takes the form of spending time outdoors, an interest in and knowledge of plants, and watching science-related TV programmes, among others. Such genuine parental interests and hobbies in turn facilitate children's early interest in science (Dabney et al., 2013). Positive parental attitudes and practices result in children acquiring and forming science-related habitus which will then have a lasting impact as characteristics of early socialisation in the home and family form the basis of all subsequent experiences (Bourdieu, 1992).

In addition, in my data, I found limited effects of some of the common structural factors such as socio-economic status. Most Turkish immigrant parents did not consider SES as a limiting factor, and I found no statistically significant association between parents' SES and students' science attitude and participation. Furthermore, survey analysis suggested that most Turkish minority students did not feel that their ethnic background generates structural limitations to act as a barrier to what they can achieve in science.

9.2.3 Development of science capabilities

The theoretical model presented in Chapter 3 argued that students' endowment with initial science-related resources is only part of a more complex capability and functioning formation process. That is, I argued that the conversion of initial resources into capability sets is a key mechanism to understand the role of outside-school factors in Turkish immigrant students' science attitude and participation. Amartya Sen's capability approach (1997; 1999) provides a very useful perspective here to link initial resources to capabilities, and to understand the process of resource to capability conversion. The basic reasoning behind this approach is that it is not sufficient for individuals to have resources or the end products of these resources (e.g., income, status, money, etc.), but they should be able to develop their capabilities (Nussbaum, 2000; Sen, 1999), and agency can play a critical role in this process.

Qualitative and quantitative analyses reported in Chapter 6 and Chapter 7 indicated that science-related capability development is a complex process driven by both agency and structure. My analyses identified several positive conversion factors for Turkish minority children's science-related capability development. These factors included children's English literacy, parents' positive involvement and science-related activities with children. Indeed, my survey data suggested strong association between these factors and students' likelihood of being in the 'high' science capability group (vs low or medium groups). These findings were also supported with qualitative analyses which identified a group of parents who actively match their positive science attitude with concrete actions, such as discussions about science lessons, nature, animals etc., going to museums with their children and buying science-related books for them, among others. These parents do not necessarily have great resources or economic, social or cultural capitals, but still they have a desire to activate capitals (Vincent et al., 2012) and a more conducive home 'field', even if such capital is limited for them. In addition to such parental agency, students' cultural activities also supported their science-related capability development. In my study, I extended Bourdieu's (1986) cultural capital which typically involves structured dispositions and goods with a more dynamic view by considering active cultural actions and practices (e.g., attending plays, concerts, cultural activities such as music, dance, language, art, visiting historical sites, reading books). My findings indicated a significant relationship between students' general cultural activity and their science-related capabilities.

The above points highlighted the role of agency and associated positive conversion factors for students' science-related capability development. However, science-related capability development is not a simple or always positive process. Although agency can help develop science-related capabilities, these are not independent of structured characteristics, inequalities and corresponding reproduction process (Bourdieu & Passeron, 1990), which are commonly faced by immigrant families (Carreon, Drake & Barton, 2005; Turney & Kato, 2009).

Indeed, existence of some conversion factors depends on the presence of certain types of capitals in the first place. That is, lack of capital can simply block an agency driven conversion factor. For example, a notable group of parents in my data indicated their desire to spend more time with their children on activities broadly related to science (which could have acted as a positive conversion factor), but their work demands (lack of economic capital) or limited knowledge and familiarity with public science engagement settings (lack of social capital) did not allow them to do so. In addition, even if the conversion factor exists and related actions takes place, the benefit received from it and the subsequent capability development would be significantly inhibited as a result of limited capitals. That is, even if the parents in my study had the opportunity to, for example, visit a museum or science centre, as minority ethnic groups, they may get a 'not for us' feeling on such visits (Dawson, 2014a), due to their lack of cultural capital.

My data also revealed several potential structured limitations related to the 'field' that are not conducive to science-related capability development. Two of these were the neighbourhood in which the family lives (e.g., some parents' comment: "not in this neighbourhood") and the physical environment (e.g., small council flat vs a house with a garden). After all, various capitals are invested and their values are realised in a field whose structure is the source of the specific effects of capital (Bourdieu, 2002). Indeed, my data revealed some parents who indicated that they could have done gardening with their children if they had a garden of their own, or could perhaps have undertaken exciting experiments if they had a larger kitchen. Similarly, some parents highlighted how their neighbourhood acts as a barrier to children's capability development. Yet, despite these concerns about structured limitations, a negative effect of neighbourhood field for Turkish minority children was not always found. In fact, my survey analysis using students' neighbourhoods' deprivation indices found no statistically significant association between students' neighbourhoods and their science capabilities. In addition, a notable percentage of high science capability students in my data (30%) were found to live in highly deprived neighbourhoods, suggesting that despite structural limitations such as living in a highly deprived area, students can still develop high science capabilities.

9.2.4 Development of science functionings

As discussed in Chapter 3, Sen's capability approach makes a critical distinction between functionings (outcomes achieved by individuals) and capabilities (ability to achieve desired functionings). Such a distinction helped in my study to better understand and distinguish between formation of science capabilities versus formation of science functionings, and associated conversion factors.

I argued in my model that what matters most is for students to develop science-related capabilities, even if they are not necessarily translated into science-related functionings. For most students, from an agency perspective, it should not be a concern if they do not choose a science career so long as they are well-informed about science, and they developed strong science-related capabilities, but of their own choice and free will choose to pursue another career path. Indeed, in my data, as presented in Chapter 7, I found that a group of Turkish immigrant students have high science capabilities but low science aspirations and career choices. What could be driving such lack of science-related career choices for students with high science capabilities in my data? Although I argued that developing science capabilities for students should be the priority, still, from a science education and policy point of view, it is important to identify functioning (e.g., career choices) developing conversion factors as students' lack of science participation and corresponding career choices is an on-going concern (Roberts, 2002; DIUS, 2009; EU Skills Panaroma, 2014).

In transforming science capabilities into science functionings, my analysis identified three major conversion factors. These include awareness of a wide range of career choices associated with science (not just becoming a scientist) and parental aspirations and attitudes to science-related careers. I also found in Chapter 6 that another critical conversion factor to science functionings is availability and access to interpersonal role models in science, which was highly limited for Turkish minority students in the UK. That is, while most of them have distant role models (i.e., doctor, science teacher friends, relatives in Turkey), they had limited access to intimate and reachable role models in the UK. Previous research has highlighted that students decide to pursue science in large measure because they identify with key people

(Rodd, Reiss & Mujtaba, 2013) and they have interpersonal relationships to role models in science (Sjaastad, 2011). In the absence of such role models and key people in the UK, my data indicated that a notable portion of Turkish minority students' inspiration and motivation to choose science education and science-related careers was limited.

The third question in my thesis sought to identify other outside-school factors that may promote or inhibit immigrant Turkish students' attitudes and aspiration in science. While the literature review and the developed theoretical framework was helpful in identifying certain outside-school factors related to cultural contexts and families that influence Turkish children's science participation, part of the thesis was exploratory in nature in that it sought to identify new elements associated with students' development of science capabilities and functionings. Several such factors were identified through the analysis of survey and interview data.

First, in addition to parents' English literacy which has been identified previously (Turney & Kao, 2009, Zhou & Bankston, 1996), an interesting and possibly surprising finding in the study was that there is a strong link between students' own English literacy and their science capability development. Even if students have oral proficiency in English, they may still lack written and comprehensive fluency which can be detrimental when attempting to assimilate scientific material in lessons, or become effective communicators in science. Indeed, as found in my study, students' good oral skills may mask problems in other areas of literacy such as comprehension or reflection which may be essential for science learning (Cullison, 1995; Fradd, 1995). In addition, considering most parents' limited English skills, such nuanced dynamics are unlikely to be detected by the parents. Secondly, physical space (having a garden, a large enough kitchen) has been identified as a conversion factor in Turkish minority students' science-related capability development. It seems that science-related capability development is not independent from such spaces. After all, an important part of science-related activities that can be done with parents, such as planting, trying simple experiments or cooking, takes place in a specific space, and the absence of a conducive setting may act as a negative conversion factor.

Also, in developing science functionings, the lack of personally connected and accessible role models was found to be a major deterrent in the conversion of capabilities to functionings. Unlike in Turkey where such personally linked role models seem to exist, Turkish immigrant students had limited access to intimate role models in the UK, which in turn acted as a negative conversion factor for science aspirations.

9.2.5 Immigrant students' science capability and functioning development: Home vs abroad

The final and fourth research question in the thesis explored how immigrant Turkish students are similar or different in their science capability and functioning development compared to their counterparts in Turkey. Admittedly, this is a major research question which has a larger scope than initially anticipated, and the question itself may warrant a doctoral thesis of its own with a formal comparative study. In this thesis, due to resource and time limitations of a single student researcher who undertook the study, this question is only partially addressed. Nevertheless, despite their limitations, the findings as outlined below, provided useful complementary insights into Turkish immigrant children's formation and expansion of science capabilities. Although the focus of my thesis was Turkish minority children in the UK and the role of outside-school factors in developing and expanding their science capabilities, in order to better understand this process, and in particular to get deeper insights into the role of being immigrant, in Chapter 8, I conducted an additional analysis comparing those students who were in Turkey and those who were in the UK. While there are clearly many differences between the education systems and educational practices of the UK and Turkey, if I can identify some systematic differences in science-related resources, capabilities, functions and associated conversion factors between students in the two countries, then these may potentially highlight advantages or disadvantages for children of being immigrant.

For this work, I conducted the same survey I used in London in five schools in Istanbul. Similar to the UK, for my survey in Turkey, I had a mix of maintained schools and independent schools. Also, to increase consistency and comparability of this analysis, as the two London schools in my survey had OFSTED ‘good’ ratings, I chose schools in Istanbul which have good profiles[8].

I compared the two groups of students in Turkey and in the UK in light of the theoretical model with a particular focus on students’ initial science-related resources, capabilities and functionings. I found that compared to students in Turkey, Turkish immigrant students in the UK had slightly higher initial resources, with their parents having higher educational backgrounds and also parents demonstrating slightly more positive attitudes towards science.

However, despite being endowed with slightly higher initial science-related resources, surprisingly, immigrant students in the UK appeared to have lower science capabilities than their counterparts in Turkey. When I more closely examined associated conversion factors, students in Turkey appeared to have greater parental interest and involvement in outside-school science activity compared to Turkish immigrant students in the UK. This may be a result of greater limitations of time and work demands for immigrant parents in the UK as described in Section 6.2.1 or because of greater structured limitations experienced by Turkish immigrant parents in outside-school science settings (Dawson, 2014) as discussed in Section 9.2.3.

More importantly, the gap between the two groups of students was even higher for science functionings. That is, I found that students in Turkey have significantly higher science aspirations and career choices than Turkish students in the UK, which could be partly explained by having greater and more personal access to science-related role models in Turkey and having much more positive images of scientists compared to Turkish immigrant students in the UK.

These findings suggested an interesting phenomenon. On one hand, many aspects of science education in Turkey are arguably behind the UK. In the PISA 2015 science results, Turkey had a below average score of 425 and ranked 54th, whereas UK was well above the average with a score of 509 and ranked 15th (OECD, 2016). Previous research has highlighted a notable set of problems in science education in Turkey

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[8] While there are no official ratings of schools in Turkey, based on my discussions with local educational administrators in Istanbul, I picked schools which they described as ‘good’ which were above average but not outstanding compared to other local schools.

including large class sizes, an overloaded curriculum, inadequate teacher training, too much emphasis on delivery of information and lecturing and very limited experiment/lab opportunities, among others (Ozden, 2007). In addition, arguably there are many more opportunities (parks, science centres, museums etc.) in the UK for public/parental engagement with science compared to in Turkey. Furthermore, my results indicated that Turkish minority students in the UK were endowed with slightly higher initial science-related resources. Despite all these seeming advantages in the UK, in my data it still appears that on average immigrant Turkish children in the UK have lower science capabilities and science functionings than their counterparts in Turkey. This may indicate that the lack of certain conversion factors such as accessible/personal role models or structured limitations for Turkish immigrant children in the UK may dominate other opportunities or in-school science education advantages provided in the UK compared to Turkey, resulting in Turkish minority students in the UK demonstrating lower science capabilities and functionings than their counterparts in Turkey.

Indeed, immigrant Turkish children in the UK may have lower science capabilities and science functionings than their counterparts in Turkey precisely because of their disadvantaged position in the UK, a different field. Previous research suggests two major dynamics that may be at play. First, the nature of science that is taught in schools in England may put immigrant Turkish children at a disadvantage in that it may be linguistically inaccessible, hard to identify and engage with, and highly authoritative (Brown, 2006; Osborne & Dillon, 2008; Reiss, 2004). Secondly, immigrant Turkish students may experience discriminatory social practices, prejudice or judgement in relation to science learning (Carlone, 2003; Rahm & Ash, 2008; Roth & Calabrese-Barton, 2004; Wong, 2011). Even those middle-class Turkish immigrant parents who can deploy wider resources and strategies for their children may still be subject to inequalities that can limit the extent of their potential class advantage (Archer, 2010). As Turkish students in Turkey would not be subject to such disadvantages related to being ethnic-minority (although class- or gender-related disadvantages may certainly be at work), formation and expansion of their science-related capabilities and functionings would be higher than those in the UK.

Of course, one has to be cautious in interpreting the aforementioned unexpected results. In the absence of a more comprehensive, large scale comparative study conducted in comparable schools in Turkey and in the UK with similar student/parent profiles and in-school factors, and in-depth interviews with teachers, parents and children, these should be considered as preliminary findings of an initial small sample study that should be followed up and verified or refuted by future research. As an alternative to a larger scale comparative study, more accurate comparisons of science capability and functioning of Turkish students in Turkey and Turkish students in the UK could be conducted by carefully picking children from similar families (in terms of socio-economics and cultural practices) who happen to be living in Turkey vs in the UK and going to similar schools in the respective countries. After teasing out effects related to social location, class, familial characteristics, in-schools factors, etc., a quantitative comparison combined with in-depth interviews or an ethnographic study could provide a more accurate picture of science-related capability and functioning development in Turkey vs in the UK.

9.3 Implications for policy and recommendations

In this section, I discuss potential policy implications of my study and provide a number of suggestions for policymakers and science educators.

9.3.1 Distinguishing between science capabilities and science functionings

An advantage of my two-stage theoretical model is that its relative simplicity makes it quite flexible and practical in addressing potentially important policy questions about the role of outside-school factors in science education. My theoretical framework can help science educators clarify the distinction between outcomes (i.e., functionings) and the ability to achieve these outcomes (i.e., capabilities) related to science education. This distinction is also related to the debate on the role of science education for society (Millar, 2014). If the primary goal of science education is to produce a scientifically literate population who are knowledgeable and well-informed about science (Osborne, 2007; Osborne & Dillon, 2008), then a focus on formation of science capabilities and associated conversion factors linking initial resources to capabilities would be appropriate. However, if the goal is to generate the next generation of scientists and broadly support STEM careers, then a focus on formation of science functionings and conversion factors that help transform developed capabilities into actual functionings in terms of further education and career choices would be suitable.

9.3.2 Supporting outside-school factors with a particular focus on family

Policy decisions with regards to outside-school factors can take place at a number of levels. At a national level, it seems possible that more students would develop their science-related capabilities if there was more alignment between within- and outside-school factors in encouraging students and parents to engage with science. At present, it is still the case that there is an implicit presumption that within-school factors are the important ones in facilitating both learning and engagement with science and that outside-school factors are a 'nice to have'. Equally, at the within-school level, it seems likely that individual science teachers would do well to make more explicit the contributions of both within- and outside-school factors to learning and engagement in science.

The findings in Section 9.2 highlighted how outside-school factors that are particularly related to family contexts and associated out-of-school experiences influence Turkish minority students' science attitudes and participation. The significance of family influence is, of course, not confined to children of immigrant parents. The first take-out point in the recent Wellcome Trust report on young people's views on science education as part of Science Education Tracker (SET) was that: "Family are the biggest influence as to how young people perceive and interact with science" (Hamlyn, Matthews and Shanahan, 2017, p.24). However, immigrant parents often face additional challenges and barriers in their science involvement as highlighted by my findings and also in the existing literature (Turney & Kato, 2009; Dawson, 2014; Archer et al., 2015). For example, in the maintained school in London where I collected my data, the school employed a part-time Turkish students' liaison person (i.e., an experienced former teacher of Turkish origin) whose job was to support Turkish minority students in the school and also act as a bridge between the school and parents. I believe this is very positive step and could be extended to other comparable schools. In addition, the current role of the liaison person mostly involved dealing with and addressing problematic issues concerning Turkish students at school as they emerge. However, considering my findings, such a person or role could take a more out-of-school and proactive approach with parents by perhaps organising and leading visits for parents to science museums, by suggesting and demonstrating simple science-related activities with children, or by arranging workshops or community events to help improve immigrant parents' access to and knowledge of the education system and its practices.

9.3.3 Engaging immigrant families with familiar activities

Student interest in science is partly driven by parental interest, such as hobbies and informal activities (Dierking & Falk, 1994; Dierking et al., 2003). So, as discussed in Sections 6.3.3 and 7.3.3, one can expect improvements in students' science participation and attitudes if school science is supported and actively engaged by parental actions. But for immigrant parents, there is usually a significant gap between home and school 'fields', and their corresponding cultures. Parents' limited English language skills can also increase this gap. Considering these, engaging parents with science-related activities in school within their own familiar domains could be a very useful way to increase parents' as well as students' science engagement.

Indeed, Calabrese Barton et al. (2001) found that when mothers talk about familiar contexts such as food, nutrition and child care, their perceptions of science were more dynamic. Similarly, in a study involving immigrant mothers in a teaching science for food programme in a middle school, Hagiwara, Calabrese Barton and Contento (2007) reported that when immigrant mothers' cultural and linguistic differences were treated as strengths, and when they were given the opportunity to bring their own knowledge and interests such as farming, cooking and health to the learning process into the classroom, then they become co-partners in their children's science education.

Similar programmes or simpler versions in schools or local communities involving Turkish immigrant parents access to science through familiar domains such as food, cooking, planting, etc. could be a very promising and effective way for their science engagement and for closing the gap between students' home and school 'fields' for science.

9.3.4 Access to interpersonal role models for ethnic minority children

As discussed in Section 6.4.3, Turkish minority students' lack of personally connected role models was a main barrier in their science-related functioning development. It was also potentially one of the lead drivers of Turkish minority students' lower science-functioning scores compared to their counterparts in Turkey, where they had easier access to interpersonal role models. But how can we increase ethnic minority students' role model access? Existing research suggests that rather than celebrity scientists or distant role models, whose effects are limited in influencing students' science aspirations or science careers (Gilmartin et al., 2007; Buck et al., 2008), role models with interpersonal relationships are a critical source of inspiration to science and science careers (Sjaastad, 2011).

Therefore, it appears that the closer and more personally connected the role model is, the greater the influence on the student for science functionings. While for Turkish minority students in the UK it would be ideal to have close and personally connected role models in science, such as relatives and family friends, it seems that this is not possible for most immigrant parents in the UK. In addition, as my findings in Section 6.3.5 indicated, their 'fields' involving neighbourhoods and the social environment did not have role models in science. However, this does not mean that there is no policy which can help address this problem. For example, interpersonal or close role models do not have to be family or other relatives, there may be similar influential effects with other role models who have personal connections with the student.

Indeed, in one of my interviews in the ANS School, a science teacher enthusiastically talked about one of their school trips to Cambridge University in which their tour guide was a former pupil of their school. She explained how students' interactions with him that day made a lasting impact on their university perceptions and aspirations. Cambridge was an unimaginable place for them before, but after that day when they saw and interacted with a "normal person" just like them but who is now studying at Cambridge, many students started talking about applying to, studying at or graduating from Cambridge. That is, even a one-day interaction appeared to make a difference, at least started conversations, and made some students think that high aspirations are attainable because they had a personal connection with the role model. In addition, the teacher noted, it would probably not be as influential and effective if it was just a seminar given by this student, rather than a whole day of active and personal interaction with him at Cambridge.

While I realise such one-time events might not be the solution to all role model concerns for ethnic minority children, I think this demonstrates how such personally connected role models could make a difference in students' aspirations and career choices. Therefore, a suitable policy suggestion could be to consider ways to improve role model visibility and personal interactions for ethnic minority students outside the school.

9.3.5 More research on 'other' ethnic minority groups' science participation and engagement

While conducting my research, one thing I noticed was how little research has been done in the UK on Turkish minority students and their science participation, despite their sizable population. Previous research noted that there are major differences between ethnic minority groups not only in terms of family and cultural practices, but also in terms of students' science experiences, attitudes and aspirations (DeWitt et al., 2010; Elias et al., 2006). In addition, according to the Migration Observatory at Oxford, as of 2015, the UK population was 13.5% foreign-born (up from 7% in 1993) with foreign-born people constituting 41% of inner London's population (Rienzo & Vargas-Silva, 2017). The immigrant profile in the UK is also rapidly changing with Poland now being the most common foreign country of birth, followed by India, Pakistan, Ireland, Germany, Romania and Nigeria.

Therefore, research and policy questions in science education on immigrant and ethnic minority children should be aware of this wide range of diversity and dynamic nature of the immigrant and ethnic minority population in the UK. Although there is relatively more work in the literature on science attitudes or aspirations of students from historically bigger ethnic minority groups such as Black African/Caribbean, Pakistani, Bangladeshi, Indian or Chinese communities, there is much less work on others. Therefore, for better-informed policy decisions in science education, more work is needed to recognise this diversity and to study 'other' minority and immigrant students' science participation, even if certain common threads are found to run though these various populations.

9.4 Limitations and suggestions for future research

My study sought to improve our understanding of the role of outside-school factors in students' formation and expansion of science capabilities in the context of Turkish minority students living in London. I contribute to science education knowledge by introducing a new theoretical framework and by providing an empirically based understanding of the role of outside-school factors using a mixed-methods approach. However, my study had several theoretical and empirical limitations which must be noted. These limitations also present future research opportunities. I discuss these limitations as well as potential future research directions below.

First, while I outlined several important conversion factors in my theoretical model and empirical study, I do not provide a comprehensive list of all the conversion factors related to children's science-related capability and functioning development. There may be further outside-school factors which influence capability or functioning development. Future research could consider identifying and studying other potential conversion factors.

Also, conversion factors may not be the same for everyone; while some children may be well equipped with certain conversion factors, others may lack these. Considering my earlier discussions, the existence of conversion factors is also likely to depend on social structures. Future work could extend my theoretical model by considering other conversion factors as well as their relationship and interactions with economic, social and cultural capital, habitus and field.

In addition, in developing and expanding students' science capabilities, clearly many in-school factors can play a role such as science lessons, in-class practices and pedagogies, science teachers, school-based factors, etc. Such in-school factors, which have been studied extensively in the literature, were outside the scope of my study. A novel aspect of my study was that I introduced and used Sen's capability approach as a lens to conceptualize and better understand the role of outside-school factors in students' formation and expansion of science-related capabilities. There can be future research opportunities to use Sen's capability approach to better understand and study students' in-school science experiences.

With regards to qualitative and quantitative analyses, generalisability of the findings is an important issue. In my study, using a mixed-methods approach helped me to develop a deeper and broader understanding and to better address the research questions with improved triangulation. But this also limited the size and scope of each of these studies. Both my qualitative and quantitative analyses were based on relatively small-scale studies based on data from two schools in London (and five in Istanbul), so one should be cautious in interpreting the findings and generalizing them to other settings, other students, or other groups.

For data collection in the two schools in London, school administrators and science teachers were very helpful in helping me to access a diverse range of students and parents with varying science attitudes, aspirations and attainment. However, despite all the support from schools, recruitment of parents and students for the interviews was a challenge. In the end, I was able to conduct a good number and variety of interviews, but still there may be slight bias, particularly for parents' participation of the study. For example, parents who are particularly concerned about their children's science participation might be more willing to participate or, in contrast, parents who are particularly proud of their children's science achievements might be more willing to take part in the study.

As a doctoral study of an individual student, my work had time and resource constraints. Also, the focus of my study was not how students' science capabilities and functionings change over time from one school year to another or for students of different ages. As a result, I did not conduct the survey with students multiple times or over a number of years. Similarly, I did not focus on age- or year-based differences in science capabilities. Recent research has considered some of the time-based issues related to students’ science aspirations and participation in large scale studies conducted over multiple years such as in the ASPIRES (Archer et al. 2013; DeWitt & Archer, 2015) and UPMAP (Mujtaba & Reiss, 2014; Mujtaba, Reiss & Hodgson, 2014) projects. My study could be extended by considering changes in students’ science capabilities and functionings over time in larger scale studies.

In my study in Chapter 8, I conducted a comparative analysis of science capabilities and functionings of Turkish minority students in the UK and students in Turkey. While the analysis and findings were informative, and they provided me with useful insights, this work had significant empirical limitations. Clearly, students from the five schools in Turkey were not representative of all students in Turkey and, similarly, the Turkish minority students in the two schools in the UK did not represent all Turkish minority students in the UK. So, generalisability of these findings is a limitation. In addition, as described in Chapter 8, for my data in Istanbul, although I worked hard to identify schools that were similar to the two schools in the UK both in terms of student profiles and school profiles, still there are many factors in science education that are different between the two countries. This made it hard to make direct comparisons. Therefore, the results in Chapter 8 should be considered to possess more of an exploratory nature. However, this initial analysis could be extended in future research by conducting a large-scale comparison of students’ science resources, capabilities and functionings in the two countries.

Finally, as a doctoral researcher of Turkish origin, throughout this study, I conducted all data collection as well as translation of data and documents between the two languages Turkish and English myself. Although this was helpful for consistency of my study, this might have brought certain biases in my data collection and analysis.

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Appendix 1: Letter of ethical approval from UCL Institute of Education for this study

Ms Hazel Croft
Faculty of Children & Learning
Dean of Faculty: Professor Richard Andrews

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Ms Tuba Gokpinar

19 April 2013

Dear Ms Gokpinar

Ethics approval

Project title: The role of families on the attitudes that Turkish children in London have to science

I am pleased to formally confirm that ethics approval has been granted by the Institute of Education for the above research project. This approval is effective from 27 March 2013.

I wish you every success with this project.

Yours sincerely

+++++++++
Hazel Croft
Research Student Administrator
On behalf of the Faculty of Children & Learning Research Ethics Committee

cc: Professor Michael Reiss
IOE Research Ethics office

Appendix 2: Sample of information sheet for school principal and teachers

Tuba Gokpinar
PhD student
Department of Curriculum, Pedagogy and Assessment
Faculty of Children and Learning

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March 2013

Understanding Students' Attitudes to Science and Science-related Careers

Project Information Statement to School Principal and Teachers

My name is Tuba Gokpinar, and I am a PhD student at the Institute of Education, University of London (IOE). I am conducting research in science education under the supervision of Prof. Michael Reiss. I invite you to consider taking part in this research. This study will meet the requirements of the Faculty Research Ethics Committee (FREC) of the IOE.

Why is this research being done?
Recent research suggests that many students find little interest in studying science, and they often express a 'not for me' attitude towards science careers. Noticing the importance of outside school factors, especially those related to family, cultural contexts and parental involvement on students' attitudes towards science and their career aspirations, my research examines the role of outside school factors in the context of Turkish immigrant children.

How will this research help?
My aim with this work is to contribute to the science education literature by identifying critical factors and examining the underlying mechanisms that affect Turkish students' attainment and aspirations in science. I also hope that my research will be of practical value to the Turkish immigrant community in London. At the end of this project, I plan to produce reports and practical documents to be shared with Local authorities (those with a high population of Turkish minorities), the Turkish community and cultural centres in London.

Who will be in the project?
For my research, I would like to collect data from teachers and the headteacher/principal, from the students at your school, and from their parents.

What will happen during the research?
Although my research is primarily about outside school factors, I would like to get a sense of students' varying degrees of interest in science both inside and outside the classroom. That is why, first, I would like to start with in-class observations (Years 7 and 10). Next, after completing my observations, I would like to conduct in-depth interviews with science teachers to get insights on what they think are the key outside school factors that may influence students' attitudes, aspirations and attainment in science. I then plan to interview students (at least 10) and then their parents (at least 10). Finally, I will conduct a survey with both students and parents to obtain more detailed insights about my research questions. If needed, some or all of the parent interviews and surveys may be conducted in Turkish. Any

related documentation (e.g., information sheet, consent forms, etc) will then be translated to Turkish.

What will happen to you if you and your school take part?
Once I receive your consent, I will then:

- arrange a time with you for initial in-class observations and teacher interviews
- arrange for informed consent to be obtained from students and their parents
- arrange student and parent interviews
- conduct a survey with students and parents.

How do I plan to address ethical and confidentiality issues?
It is up to you to decide whether you wish to take part in this research. Even if you say ‘yes’, you can drop out any time or say that you don’t want to answer some questions. Also, I am not going to use any real names, I will anonymise the data, and I will keep the data in a safe secure place. I will not tell anyone what you tell me during this research unless I think someone might be hurt. If so, I will talk to you first about the best thing to do. I will also send you a short report of my findings three months after I complete my data collection.

Attached for your information are copies of the Parent Information and Consent Form and also the Participant Information Statement and Consent Form. If you would like your school to participate in this research, please complete and return the attached form. I would be grateful for your participation.

Thank you for taking the time to read this information.

Yours sincerely,

Tuba Gokpinar
PhD Student

Appendix 3: Sample of consent form for school principals

Tuba Gokpinar
PhD student
Department of Curriculum, Pedagogy and Assessment
Faculty of Children and Learning

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March 2013

Understanding Students' Attitudes to Science and Science related Careers

School Principal Consent Form

I give my consent for you to approach students in Year 7 and Year 10 and their parents to participate in your research project.

I have read the Project Information Statement explaining the purpose of the research project and understand that:

- The role of the school is voluntary.
- I may decide to withdraw the school's participation at any time without penalty.
- Students and their parents will be invited to participate and permission will be sought from students and also from their parents.
- Only students who give consent and whose parents give consent will participate into the interviews.
- All information obtained will be treated in strictest confidence.
- The participants' names will not be used and individual participants will not be identifiable in any written reports about the study.
- Participants may withdraw from the study at any time without penalty.
- A report of the findings will be made available to the school.
- I may seek further information on the project from Tuba Gokpinar via e-mail and the telephone number provided above.

Name: Signature

____
Date

Researcher's name Tuba Gokpinar (PhD Student)_______

Signed ____________________________ Date ________________

Appendix 4: Sample of consent form for teachers

Tuba Gokpinar
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March 2013

Understanding Students' Attitudes to Science and Science related Careers

Consent Form for Teachers

I have read the information leaflet about the research ☐ (please tick)

I agree to be interviewed ☐ (please tick)

I understand that I can opt out from this study at any time without any need to provide a reason ☐ (please tick)

Name ______________________________

Signed ______________________________ Date ___________

Researcher's name Tuba Gokpinar (PhD Student)

Signed ______________________________ Date ___________

Appendix 5: Sample of information sheet and consent form for parents (English and Turkish)

Tuba Gokpinar
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March 2013

Understanding Students' Attitudes to Science and Science-related Careers

Project Information Statement to Parents

My name is Tuba Gokpinar, and I am a PhD student at the Institute of Education, University of London (IOE). I am conducting research in science education under the supervision of Prof. Michael Reiss. I invite you to consider taking part in this research. This study will meet the requirements of the Faculty Research Ethics Committee of the IOE.

Why is this research being done?

Recent research suggests that many students find little interest in studying science, and they often express a 'not for me' attitude towards science careers. I investigate factors that may affect student attitudes towards science in the context of Turkish immigrant children.

How will this research help?

I hope that my research will be of practical value to the Turkish immigrant community in London. At the end of this project, I plan to produce reports and practical documents to be shared with Local authorities (those with a high population of Turkish minorities), the Turkish community and cultural centres in London.

Who will be in the project?

For my research, I would like to collect data from teachers and the headteacher/principal, from the students at your school, and from their parents.

What will happen during the research?

I would like to conduct interviews with science teachers, students and their parents. Then, I will conduct a survey with both students and parents to obtain more detailed insights about my research questions.

What will happen to you if you take part?

Once I receive your consent, I will then arrange a time and a place (e.g. a premises room or a classroom in the school, your place of residence), which is convenient for you and your children for the interviews.

How do I plan to address ethical and confidentiality issues?
It is up to you to decide whether you wish to take part in this research. Even if you say ‘yes’, you can drop out any time or say that you don’t want to answer some questions. Also, I am not going to use any real names, I will anonymise the data, and I will keep the data in a safe secure place. I will not tell anyone what you tell me during this research unless I think someone might be hurt. If so, I will talk to you first about the best thing to do. I will also send you a short report of my findings three months after I complete my data collection.

If you would like to participate in this research, please complete and return the attached form. I would be grateful for your participation.

Thank you for taking the time to read this information.

Yours sincerely,

Tuba Gokpinar
PhD Student

Tuba Gokpinar
PhD student
Department of Curriculum, Pedagogy and Assessment
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Ocak 2014

Ögrencilerin Fen Dersleri ve Mesleklerine Ilgi ve Tutumları Konulu Arastırma

Aileler için Proje Hakkında Bilgi Formu

Ben Tuba Gökpınar. Londra Üniversitesi, Eğitim Enstitüsünde (IOE)'de doktora öğrencisiyim. Prof. Michael Reiss danışmanlığında fen bilimleri eğitimi üzerine araştırma yapmaktayım. Sizi bu araştırmaya katılarak katkıda bulunmaya davet ediyorum. Bu araştırma için üniversitemin etik komitesinin onayını almış bulunmaktayım.

Neden bu araştırma yapılıyor?
Yapılan araştırmalar göstermektedir ki öğrencilerin büyük bir kısmının fen bilimlerine ilgisi çok düşüktür ve genellikle fen ile ilgili mesleklere karşı 'bana göre degil' şeklinde bir tavır göstermektedirler. Bu konuda etkili olan faktörleri İngiltere'de Türkçe konuşan çocuklar bağlamında araştırıyorum.

Bu araştırmanın nasıl bir katkısı olacak?
Bu araştırmanın Londra'daki Türk göçmen topluluğu için pratik katkıları olacağını umuyorum. Bu proje sonunda, yerel otoriteler (Türk azınlıkların yüksek nüfusta olduğu belediyeler), Türk toplumu, ve Londra'daki kültür merkezleri ile paylaşılacak pratik belgeler ve raporlar üretmeyi planlıyorum

Projede kimler olacak?
Bu araştırma için, okulunuzun müdür ve öğretmenleri ile öğrenci ve velilerden bilgi edinilecektir.

Araştırma sırasında ne olacak?
Öncelikle öğrencilerle bir anket calışması yapacağım. Ardından daha detaylı bilgiler elde etmek için Fen öğretmenleri, öğrenci ve velilerle mülakatlar yapmayı planlıyorum.

Katıldığınızda ne olacak?
Sizin onayınızı aldıktan sonra, siz ve çocuklarınızla görüşme/mülakat yapmak üzere sizlere uygun olacak şekilde bir yer (örneğin okulda bir sınıf, ikamet yeriniz vb.) ve zaman ayarlayacağım.

Etik ve gizlilik konularına nasıl dikkat edeceğiz?
Bu araştırmaya katılmak sizin kararınıza bağlıdır. Katılmaya karar verip onayladıktan sonra herhangi bir nedenle devam etmek istemezseniz, araştırmadan ayrılabilir veya cevaplamak istemediğiniz soruları geçebilirsiniz. Ayrıca, araştırma raporlarında hiçbir gerçek isim kullanılmayacaktır. Araştırma tamamladıktan sonra size bulgular ve analizleri içeren kısa bir rapor gönderilecektir.

Bu araştırmaya katılmak isterseniz, ekteki formu tamamlayarak iade ediniz. Katılımınız için minnettar olacağım.

Bu araştırmaya zaman ayırdığınız için teşekkür ederim.

Saygılarımla,

Tuba Gökpınar
Doktora Öğrencisi

Appendix 6: Sample of consent form for parents (English and Turkish)

Tuba Gokpinar
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January 2014

Understanding Students' Attitudes to Science and Science related Careers
Ögrencierin Fen dersleri ve Mesleklerine İlgilerini Öğrenme

Consent Form for Parents
Aile İzin Formu

I have read the information leaflet about the research. ☐ (please tick)
Araştırma bilgi formunu okudum. (lütfen seçiniz)

I will allow the researchers to interview my child ☐ (please tick)
Çocuğumla mülakat yapılmasına izin veriyorum. (lütfen seçiniz)

I agree to be interviewed ☐ (please tick)
Şahsımla mülakat yapılmasına izin veriyorum. (lütfen seçiniz)

I understand that my children and/or I can opt out from this study at any time without any need to provide a reason ☐ (please tick)
Çocuğum ve/veya kendim gerekli gördüğümüzde sebep belirtmeden araştırmaya katılımımızı sonlandırabiliriz. (lütfen seçiniz)

Name/İsim ____________________________

Signed/ İmza ____________________________ Date/Tarih ____________

Appendix 7: List of student and parent participants for individual interviews

School	Year	Gender	Pseudonym	Parent Interviewed	Parent Pseudonym
Athenaeum	7	M	Tarik	No	-
Athenaeum	7	M	Sinan	No	-
Athenaeum	7	F	Fulya	Yes	Gonca
Athenaeum	7	F	Mine	No	-
Athenaeum	7	M	Ekrem	No	-
Athenaeum	7	M	Zeki	Yes	Nihal
Athenaeum	10	F	Derya	Yes	Gonca
Athenaeum	10	M	Cem	No	-
Athenaeum	10	F	Irmak	Yes	Tanem
Athenaeum	10	M	Numan	Yes	Tulay
ANS	7	M	Ufuk	Yes	Gonul
ANS	7	M	N/A	Yes	Vesile
ANS	7	M	Berk	Yes	Behiye
ANS	7	F	Ayse	Yes	Bahar
ANS	7	F	Gozde	Yes	Isil
ANS	7	M	Omer	Yes	Umman
ANS	10	F	Nuray	Yes	Remziye

Appendix 8: List of teacher and staff participants for individual interviews

School	Gender	Teacher/Staff Pseudonym	Role
Athenaeum	M	Mr Harris	Science teacher
Athenaeum	F	Ms Kaya	Science teacher
ANS	M	Mr Ilbert	Science department head
ANS	M	Mr Lacey	Science teacher
ANS	M	Mr Fagan	Science teacher
ANS	M	Mr Mahmut	Turkish liaison
ANS	F	Ms Bailey	Career office manager

Appendix 9: Student interview guideline

1. Which classes (subjects) do you like/enjoy the most? Which one(s) the least?
    a. Does that apply only school classes, subjects or daily life interest as well?
    b. Documentary, movie, museum, toy- history, science, art

2. Do you enjoy science lessons?
    a. Was your interest in science always like that or at some point a life event/person has an effect on it?

    (So you gradually lose/gain your interest)

3. What do you remember most about your Science lessons this year? (valuable to remember and/or find particularly enjoyed/boring)

4. What makes science easy or difficult for you?

5. How successful do you feel about using science skills in and out of class? Give an example of how you use science outside of class (eg. at home).

6. Have you ever participated in a science contest, science fair, special science activity, etc?

7. What do you want to be when you complete all your education? What is your ideal job?
    a. Have you future job changed over time or was it always same all the times?

8. Who is your role model? Why? (the careers they have, life philosophies, personalities)

9. Who are the most famous scientists you know? Where did you hear about them?

10. Do you know any doctors/nurses, chemists, biologists, science teachers, etc. in person? Any family members, family friends, neighbours? (Are they effective on your personal goals, education decisions)

11. What is your favorite TV programme? Book? (Why they are? The way….)

12. What hobbies and interests do you have?

13. What is your favourite activity that you do with your parents?

14. Have you ever worked/participated together with your parents on a science homework, science project, science fair, and science experiment or science activity? How was this experience? (Can you tell me more about this? What do you remember?)

15. Imagine your are the same person as now with same interest, passion and energy but you have different opportunities to make your dreams to come true. In that case, would you goals, possible future careers stay same or would they be different?

    a. Same: you don't see any obstacles in your way to reach your goals. Brilliant
    b. Different: what differences would they be?

    What are the different opportunities you imagine in that case?
16. Do you see any obstacles on your way that slow you down to reach your goals and/or future plans?
17. Do you see any opportunities you think you have which helps you to reach your goals and future plans?

(These can people who have ‘say’ on your decisions, any kind of financial, educational, intellectual resources and abilities- ability for science/sport: I like but I cannot understand fully, being athletic, say being short for basketball)

18. Turkey: Do you visit Turkey? Which part? How frequent? How regular?
    a. Which of your relatives do live in Turkey?
    b. How do you feel when you are in Turkey? Why?
    c. Where do you feel yourself belongs to Turkey, UK? Identity? Getting used to? Home?
    d. Return? Future plan?

Appendix 10: Parent interview guideline (Turkish and English)

1. Kac yildir burda yasiyorsunuz? Aileniz, akrabalariniz buradalar mi?
   How long have you been living in the UK? Have you got your family members and relatives here?
2. Egitiminizi burada mi tamamladiniz? En son mezuniyetiniz?
   Have you completed your education here or? Latest graduation?
3. Calisiyor musunuz? Ne isle mesgulsunuz?
   What do you do for living?
4. Kac cocugunuz var?
   How many children do you have?
   a. Yaslari? *Their ages?*
   b. Neler yapiyorlar? *What do they do?*

5. Cocugunuzun <u>okul deneyimi</u> hakkinda ne dusunuyorsunuz?
   What do you think about your child's school?
   a. Bir azinlik olarak <u>karsilastiginiz zorluklar</u> oluyor mu? Neler?
      As being a minority do you feel any challenges?
   b. Bu konularda okulun destegini goruyor musunuz? Neler yapilabilir?
      Any support on these issues? What types of support can be helpful?

6. <u>En cok sevdigi</u> derler? En az sevdikleri hangileri? Sizce neden?
   Which classes (subjects) do you think your child likes/enjoys the most? Which ones the least? Why?
   a. Fen derslerini seviyor mu sizce? Neden?
      Do you think your child enjoys the science lessons? Why, why not?

7. Cocugunuz icin <u>ideal meslek</u> ne sizce? Sebepleri?
   What do you think is the ideal job (career choice) for your child? Why?
   a. Peki kendisi ne olmak istiyor?
      What about his/her choice as a job?
   b. Fenle ilgili bir meslek sahibi olmasini ister misiniz? (Bilim insani? Doktor, kimyager, biyolog vb)
      What about a career for him/her related to science? Being a scientist? Being a doctor, nurse, chemist etc?
   c. Sizce bu meslekleri yapmak icin herhangi bi engel var mi onunde?
      Do you think are there any obstacles to reach these goals?

8. Hic daha once fenle ilgisi olan bir isle ugrastiniz mi?
   Have you ever done a job that was related to science?
   a. Fen <u>bilimlerine ilginiz</u> var mi? Bilimle ilgili haberler, belgeseller, dergiler?
      Do you yourself have an interest in science? Science related news, documentaries, magazines?
   b. Fen bilimleri ile ilgili isleri olan tanidiklariniz var mi? (doctors/nurses, chemists, biologists, science teachers, etc). Ailenizde, akrabalariniz, aile dostlariniz, ya da gorustunuz komsularinizdan?
      Do you know anyone in person with a science related job? (doctors/nurses, chemists, biologists, science teachers, etc). Any extended family members, friends, neighbours?
   c. Yaptiklari is hakkinda ne dusunuyorsunuz?

What do you think about their occupation?

9. Cocugunuzda ne gibi aktiviteler yaparsiniz?
   What kind of activities are you involved in with your child?
   a. Onun mesgul olmayi sevdigi aktiviteler neler?
      What is his/her favorite activity?

10. Cocugunuzun odevleriyle mesgul olur musunuz? Ne derece ilgilenirsiniz?
    Are you involved at your child's education at home and/or at school? At what level?
    a. Hic bir fen odevi, projesi uzerinde birlikte calistiginiz, fikir alisverisi yaptiginiz oldu mu? Ya da bir muzeye, bilim fuarina katildiginiz?
       Have you ever worked together with your child on a science homework, science project, science fair, science experiment, or science activity (visiting a museum, etc)?
    b. Nasil bir deneyimdi?
       How was this experience?

11. Evinizde bilimle ilgili kitap, dergi, oyuncak, maket var mi?
    Have you got science books, magazines, toys, experiment kits at home?
    a. Kimler alir bunlari?
       Who gets home these?
    b. Hic boyle hediye aldigi oldu mu, sizden ya da cevrenizden?
       Have you ever bought your child a science gift or a toy? Or from someone else?
    c. Sever mi boyle seyleri?
       Did he/she enjoy it?

12. Turkiyeye ne siklikla gidiyorsunuz? Gittiginizde neler hissediyorsunuz?
    How often do you visit Turkey? How is your experience there?
    a. Yerlesme planlariniz var mi?
       Any plans about moving to Turkey?
    b. Kendinizi buraya mi oraya mi ait hissediyorsunuz?
       Feelings on belonging (home) here or Turkey?
    c. Peki cocugunuz?
       What about your child's feelings?

13. *Vision:* Cocugunuzun basarisi ve gelecekte sahip olacagi mesleklerle ilgili ne gibi desteklerin olmasini istersiniz? Okuldan, belediye ya da Turkish community centre'lardan?
    Vision: What do you think what kind of supports will be helpful for your children's education and future career?

Appendix 11: Teacher interview guideline

1. How long have you been teaching (overall and in this school)?

2. How would you describe yourself as a teacher (or as a science teacher)? (teaching approach/philosophy)

3. What do you try to achieve in science lessons?

4. Can you tell me an occasion when you felt a lesson went really well? Why do you think this was?

5. In your experience, how would you describe the distribution (percentages) of students in terms of their interest in science lessons?
    - How would you compare this with that of this school?

6. What do you think are the most important factors for <u>student attainment</u> in science?
    - What do you think are the most important factors for students' <u>career aspiration</u> and choices (in science)?
    - How do these factors that affect attainment and aspiration differ for TKC pupils?

7. What do you think is the influence of parents in forming students' attitudes towards science (in general)?
    - What about specifically Turkish students at this school?
    - Can you give me an example of how the home background of some of your students affects what they think about science?'

8. What kind of inside/**outside** class activities do you do in science education? (e.g. visit a museum, field trip, visit a factory/science centre, project task, also the possibility of people from outside – e.g. Science Ambassadors – coming *into* schools)
    - Do any of these activities involve parents? How? (finding insects, home science projects, visit a museum)
    - How would you describe <u>Turkish parents' involvement</u> in these kinds of activities?

9. Can you comment on parental involvement in this school?
    - How would you describe your relationship with parents at this school? (teacher-parent relationship)
    - What about particularly parental involvement for science classes? (parent-student relationship)

Appendix 12: Sample student interview

Irmak's interview transcript
Irmak , Female, Year 11, Athenaeum School

INT: Thank you very much again for accepting the interview. Let's start with a question. Which classes/subject do you like the most?

IRMAK: I really like English. I love psychology. I don't mind science but for example in the future I don't want to do science or maths, I like more like English and psychology.

INT: It is social sciences you like then.

IRMAK: Yeah, yeah.

INT: If I ask the question the other way around, which classes/subject you like the least?

IRMAK: I like all the subjects, but the least one would be Maths and Science, I don't really like numbers, and stuff like that.

INT: Ok, so do you enjoy it during the science lessons?

IRMAK: Yeah, I enjoy it.

Q: So, you don't seem to like science much, but you seem to enjoy the lessons?

IRMAK: Yeah, I am ok with it.

INT: What makes science lessons enjoyable or appealing for you?

IRMAK: Ehmm. I love physics, because I love like outer space and astronomy. I like learning how the world works. For example it is not the religionwise but sciencewise, for example the atomic theories, the explanations, it is a big accomplishment for the human kind. I just like studying about it. And, yeah I just like to learn the way everything works.

INT: So when you learn the details about these mechanisms, it makes you happy and enjoyable?

IRMAK: Yeah.

INT: What about your favourite topic in science? You said you like physics. Is there any specific topic or chapter?

IRMAK: Last year we did like Astronomy and like space, the way stars are created, and the black holes. I enjoyed that very much.

INT: Oh great. Ok, so if I ask you what you remember from last year the most in science lessons, what can you tell me about it?

IRMAK: In Physics, or others?

INT: Any science lessons. What you feel you remember easily, or what you think is worthwhile to remember?

IRMAK: For example I remember electrodes, the positive and the negative in an experiment. And then for example, like I said the stars, and stuff. And then insulation in houses, like when you insulate the house, the amount of energy loss. And, last year, we also did the chemicals, and like what happens when an alkali reacts with an acid. We did it not in detail, but more in brief. We also did the food chain and like when animal eats animals, and the nutrition, and the amount of animals in a certain area.

INT: So what is it that makes these things easier to remember for you?

IRMAK: Like, we did a lot of experiments, Chemistry especially, when you also think of like your mind spending more time on it, . Also like in the exam, if you remember that you did something about it, you just write it down, it is easy to remember, like when you spend more time on it.

INT: Ok, so what makes science easy for you?

IRMAK: I think, like, it is important of you like the subject. If you don't like, you are not gonna concentrate as much, and science I enjoy. It is not my favourite subject, but I think like it is easier for me because it also depends on how you interpret it. For example, if you use it in real life and you try to understand it. Like the insulation, if you use it in the future, and how energy works, or how stuff work around you, it is easier to kind of learn. Whereas if you just ignore it and you don't pick anything up, it is more difficult for you.

INT: Ok, so do you feel you are using your science knowledge or science skills? Do you feel you use science in your daily life?

IRMAK: Definitely, you use the knowledge.

INT: Can you give me any examples?

IRMAK: I mean for example in Biology, you are a human, you can use it yourself. For example, when your heart, in a hot day it expands and in a cold day narrow. It is like, you can kind of understand yourself better, it is same as psychology, the science do really help for you. For example, like I said insulation. In the future if you want to get your house insulated, you kind of know what to do and energy and everything.

INT: It is brilliant, I see you find science relevant in your daily life. Ok, what makes science difficult for you?

IRMAK: Sometimes, like I said I don't really like numbers, calculating it, the equations. So sometimes you are given in an exam, or the words may be you don't know. If you work on it, it will become easier, but first a lot of things are difficult, and like last year I did electrolysis, and we spend lots of time on it, and this kind of helped me, but had a lot of equations, and you know also lots of symbols, so sometimes is difficult to remember formulas, all they mean, etc.

INT: Ok, so do you think that those likes and dislikes, in terms of subject, are they specific to in school lessons, or are they daily life interests as well?

IRMAK: It is Psychology and English I like the most because I speak English, and I like to use big words, stuff like that, and I like Psychology, I have lots of interest on my surrounding and me, and the way I think like the negative and positive around me. For example, I don't really use Maths as much in my daily life, I mean it is more like Science, and English, it is stuff like you do all the time. Languages are also very important. So, my favourite topics, I think are those I do outside the school.

INT: Ok, I see. Have you every participated in a Science contest or Science project?

IRMAK: I did not participate, but help like building an ecosystem, and my teacher went to represent our school. But I haven't like personally gone myself.

INT: So how was that process?

IRMAK: Basically, I and my friend we had to make like in a box, Antarctica like a cold environment, and our teacher went to Turkey and spoke about it, And teachers came, and we had to make the whole scene like the penguins like that. It wasn't actually, I did not have to out any knowledge into it, it was more like making it, but that's all.

INT: Did you enjoy during that process?

IRMAK: Well, yeah it was fine.
INT: What about any learning in the meantime?

IRMAK: We learn like the habitat and animals in the habitat, and how it works and stuff.

INT: Uhm, ok. So, what do you want to be when you complete your education?

IRMAK: A barrister, like a lawyer, something in Law.

INT: Was it the case in all your life, or have you ever changed your career plans?

IRMAK: When I was really young, I wanted to be a fashion designer, because I really liked the fashion. Then I wanted to be a dentist, but I don't really like touching people's teeth. (Laughs). Now my mom and my father, other people around me, they say that I should do something in law, because I really enjoy politics, and debating, stuff like that. So, I think that as a life career, it will be good for me if I enjoy it.

INT: So, you think being a barrister or lawyer is an ideal job for you?

IRMAK: Yeah.

INT: So, at the moment you sound ambitious to be a lawyer. Any other possible routes on your way?

IRMAK: Maybe I finish being as barrister, then maybe like I can go into fashion, maybe just as a side course, because I have a big interest in it. Maybe dressing up, drawing, yeah.

INT: Ok, good. Do you have any role models? It can be those people and their jobs, or their personality, their life philosophy, anything.

IRMAK: Role models I have are, I mean, for example, a model or an actor; it is not like really anything stupid I want to be but my biggest role model is Johnny Depp. Because, he might be an actor, but as in, his characters are very strong, and the way he thinks I like it. When he was young, a lot of people said that he wouldn't do anything in his life, but he did, and he is one of the best actors, so I have a lot of respect for him.

INT: Ok, great. So you are probably following his life closely, his interviews etc. Ok. Have you got any other person as a role model?

IRMAK: I look up to my mom and dad a lot. But I wouldn’t say a role model, but more like guidance and they help me. And people like my family and friends. They do have a big role, as in they help me and see who I am. Because sometimes you don’t see what you are doing yourself, they do help me a lot. They support me a lot.

INT: Ok, it is great. Who are the most famous scientists you know?

IRMAK: Edison, and Newton, and then Einstein.

INT: Did you hear about them in school or in any other place?

IRMAK: Yeah, at school.

INT: What about out of school? Do you read about this kind of information or hear about them in any way in your daily life?

IRMAK: Yeah, I do lots of research. For example, scientists or anything in general if I enjoy it. I speak to a lot of people out school about school. Like, most of these things are subject related.

INT: Who are they? What do you discuss with them?

IRMAK: For example, family and friends out of the school. Like we talk about, what we learn in school, and compare and share. Because some schools do different things. So we just see what they teach what I learn things like that.

Q: So, those people are generally your friends?

IRMAK: Yeah, people I see a lot.

INT: Ok, then. Do you know any people who do science related jobs? Like doctors, chemists, can you give me any examples?

IRMAK: For example, my brother, he is doing Biochemistry.

INT: Is he in the university?

IRMAK: Yes, he is doing his last year in the university. Then he will do his Masters. And then, my brother has lots of friends who do it. And I have got a cousin who is doing Math science related, and his sister who wants to become a doctor. And then I’ve got another relative who is doing Psychology science. It is very like Science.

INT: Ok, so you like Psychology, right. So, do you have any information about this from him or her?

IRMAK: Yeah, she does tell me a lot about it, what they are doing in university and stuff.

INT: Ok, what about Television and Books. What is your favourite programme?

IRMAK: I don't really watch TV programmes, I watch more like films. Usually, real life based things, like for example I have a big interest in the psychology of criminals. There is a lot of documentaries and films on that. Because I wanna do barrister in criminal law, I have a really big interest in there. And seeing it. Like at the young age, they usually have problems with their families, so it really interests me. I read a lot of books which are also true based stuff. For example, like criminals, or the way people change.

INT: Ok, so you like these more than fantasy based things. Ok. What hobbies and interests do you have?

IRMAK: Oh, I love shopping.I absolutely adore it. I also just like going to the library and revise with friends, working as a group. Not too many people, just people I see regularly. I like to be alone sometimes, just read, sit down, or think. Most of the time, this year I don't have much time do a lot of things because of revision, but usually I really like shopping and sitting down talking with friends.

INT: Ok, what is your favourite activity you do with your parents?

IRMAK: With my mum, I just like to talk to my mum. We would just go outside, and sit in, I don't know sit in a restaurant and talk.

INT: Talking about?

IRMAK: My mom and I share everything. She wouldn't mind, and she understands. My dad, obviously because he is a male, he is a bit more difficult to share. But I mean, me and my dad are very close, I am more dady's girl. But we usually go out as a family on Sundays or something, and go bowling, or do something together. But it changes.

INT: Have you ever worked together with your parents on a science homework, science project or fair?

IRMAK: Not a science fair. Like the science project I talked we did at school, I ask my brother because he does Science.

INT: Ok, your parents, or your brother, do they ask questions about your lessons, or other interests?

IRMAK: Yeah, all the time.

INT: So, you have a chance to get their opinions and visions.

IRMAK: Yes, especially, with my brothers, yeah.

INT: Oh, so you have more than one brother?

IRMAK: Yeah, I have got two brothers and two sisters.

INT: I see. So, what do they do?

IRMAK: Yeah, one of my brothers he works, at a fashion store. And the other one, he is at uni. And my sisters, one is in this school she is year 9, and the other one six years old, so she does primary.

INT: Ok, so you are in year 11, so you get some GCSEs. Which ones have you taken already?

IRMAK: I have done my core Science. I got B. And then I did History and I got B. And Turkish I got A*. So I did three.

INT: Ok, so which others would you like to take next, this year?

IRMAK: I have got English literature, English language, Maths, another Science additional Science, Psychology, Arts, PE.

INT: Ok, what's your expectation about these? Any predictions for grades?

IRMAK: English is A, Maths is A, Science is AB, Psychology is A, PE I think is B, and Geography is B, and Arts is B.

INT: For the university, do you have any target universities or departments?

IRMAK: Well, yeah. My target university is Harvard University, but it is in America, it is a bit different, because the law is different here. So, I kind of want to study in a country where I live in because it is the laws. My mom want to send me to study in America or in Canada, but. You know London School of Economics. I really want to go there.

INT: Ok, so probably you will study sixth form in the next step. Do you know application systems to America or Canada. Probably they have a different system for application?
IRMAK: Yeah, yeah, my mom has a brother in America and his wife is from Canada. So it will be easier to give me advice or to help me.

INT: Sure, sounds great. So, you have got your target universities, departments, or other targets in your life. How close do you feel yourself to reach these targets? Do you think they are just dreams, or you feel they are easy to reach?

IRMAK: It is difficult obviously every target. But people that study there, if they can do it, I don't see what makes us different. So I just feel that if I put the time and effort, and work hard, I mean anyone can do it. It is just wanting it, and actually working towards that.

INT: Do you see any obstacles on your way to achieving these?

IRMAK: Definitely, for example distractions. Like, at this age, obviously girls, boys, friendships, social networks are obstacles as well. And it is difficult at this age because you do like what everyone does.

INT: What about others, like any parental issues permissions, economic/financial resources, or educational resources, any other obstacles?

IRMAK: My mother would love me to study, they would not mind the money as long as I study. Sometimes we have family problems and stuffs that might be an effect but other than that it's ok.

INT: Ok great. Let me ask you the other way around. Do you see any opportunities, factors that may help you reach your goals?

IRMAK: In me, I find my character, I am confident, so I will set something and work towards that. Opportunities, for example my interests, taking what comes my way.

INT: Finally, let me ask you about Turkey. Do you have any friends or relatives in Turkey?

IRMAK: I have relatives in Turkey.

INT: Do you go to Turkey frequently?

IRMAK: Yes, usually once or twice a year, summer time, or sometimes Christmas.

INT: How much time you spend there?

IRMAK: I spend like 5-6 weeks.

INT: How do you feel yourself? Do you feel home is here or home is Turkey?

IRMAK: I love London, I am a very London girl. But I love Turkey. In Turkey it is like a different atmosphere, families are very big, everyone comes together. And you know when you go to the countryside, I don't really like it because of the creatures, I am not used to it, but the people there it is a nice feeling. Once a year, it is very short time, so it is nice to have a change sometimes.

INT: If you have a chance to settle somewhere in the future, where would you prefer? Here or there?

IRMAK: Definitely here. But I mean I would still go there, but I just wouldn't live there.

INT: Ok, in Turkey, other than being in a different country, how do you feel being there, relationships, people?

IRMAK: My Turkish is very bad, I can speak but it is very different. And I don't really enjoy talking in Turkish. My English is stronger. In Turkey everyone speaks Turkish, I feel like it is difficult for me. I usually love telling my mom something and then she would translate for me, but still difficult. Obviously if I settle there, I can change that, I can get better. But I am so used to the system here, Istanbul, I usually go to Istanbul, is very similar to London as a city. I speak to everyone in English my mom and dad, so when I go there it is very different first. But obviously in the future, if I go there, study there, I would not mind settling down, but at the moment I would love staying here.

INT: Ok, thank you very much, I think that's all. Thank you very much for your time and answers, these are very helpful for my work.

Appendix 13: Sample teacher interview

Mr Ilbert's interview transcript

Mr Ilbert, Male, Science Department Head of ANS

INT: So, I start directly then.

MR ILBERT: Sure!

INT: How long have you been teaching?

MR ILBERT: Teaching… I started my training 2007. I started my first teaching job in 2008 and - I pass my NQT in 2009, I guess.

INT: So how long have you been teaching in this school?

MR ILBERT: This is my second year.

INT: Well, how do you describe yourself as a teacher?

MR ILBERT: Depends on the day. Really! I suppose I would like to think myself on a good day as being positive and enthusiastic. I'd like to get kids engaged in science. Not sure that's not always the case. But that's how I see myself as a teacher. I like to get kids interested in science; I like kids doing to think about science in terms of being practical and having application on the real world and teach them the key skills. That's what I like to see myself.

INT: What do you try to achieve in science lessons?

MR ILBERT: In science lessons it is all about the progress. I want to see in the end of the lesson all kids making a good progress.

INT: Can you tell me an occasion that you felt a lesson went really well?

MR ILBERT: Amm. So I think my lessons which is gone well when that I have given a task that students take the ownership of the work and worked independently. So for example I taught a lesson on exo and endo- thermic reactions. I did give all the things to the students: all the answers, sort of keywords, and I give them a puzzle. They had to read and bring the pieces together to answer the puzzle. Independently and I wasn't rather than feeding them the information and I was getting them to problem solve and work things out for themselves.

INT: Okay. In your experience could you describe the distribution of students? I mean percentages of TKC pupils in terms of their success in science.

MR ILBERT: Okay, I don't hold a data to hand but on that considering whole school but overall in comparison to whole school, TKC pupils make progress but not in line with the other groups, I think it is getting better, for that group and especially amongst the girls and TKC girls are , I think, in a better progress than the TKC boys, I think.

INT: Do you see any specific reason behind it?

MR ILBERT: I think this is an element of expectation from home, support from home. So for instance lots of our white mid class kids are very, the parents of these kids are very much involved in their education and are very supportive and probably they help them on their homework and I think especially with the TKC students that's not the so much the case. I am doing best to try to get involve the parents as far as we getting them in and the presence of Mahmut in terms of acting as a liaison between us and them. I think there are lots of work we need to do still.

INT: So do see any specific reason behind this low parental involvement?

MR ILBERT: I think there is an issue that a lot of them weren't born in this country and English is maybe their second language, they may not familiar with the education system here and so I think those barriers which exist for a lot of parents coming from that group of students. Amm, yeah that exists. Therefore it doesn't exist the expectation that what they are going to become. I am not sure. They don't know much about university education in the United Kingdom, what opportunities available, so there is not that expectation for those student and they gone below being successful.

INT: What about career aspirations? What do you think, how do they form?

MR ILBERT: Amm, I think, amm I don't know but I am not sure what influences it to be honest. It comes down to personal preferences of subjects, what they like and what they are good at, there may be factors to do status of job and certain students may be attracted to jobs and careers which has status and money. I don't know. It is not necessarily clear for me what motives in terms of career aspiration.

INT: What about specifically science career aspirations? How do they see science careers?

MR ILBERT: I dont think, I think the once who are more able students in those groups and have a good idea about science careers and I think we could do more have people coming in and giving information about it. Then they maybe more interested and following. I think a large number of that group they don't have that much idea of the opportunities which around them in science. I think this is something as a school we need to improve in terms of having the idea what we can do in the classroom and how we can lead.

INT: So do you think those students and their parents are not well informed in terms of career opportunities?

MR ILBERT: Well I think they could be better informed and they could be more information out there, how we do there. Obviously we do career information workshop for year 10 and we have different speakers coming that are able to speak to lots of different people but fundamentally I am not sure there is enough information out there for those students.

INT: Parental involvement of TKC students. Generally speaking, how is the attendance of TKC pupils' parents in parents evening and meetings?

MR ILBERT: Yeah, I think it is a really a game. It is with all groups, there is a pattern the once a student is more able the parent is more involved. So I have got the TKC pupils in the high ability sets they are much more likely to have their parents in the parents evening and I see these parents more and ask me how their child is doing and it is less likely to be seen in the school for lower set generally there is a clear correlation in between parental involvement and pupil progress, I would say.

INT: Okay. What kind of outside classroom activities do you do for science lessons?

MR ILBERT: We have a science club, which is open to all year 7 and 8s. We need to work to get it better for next year but it meant to be open to all people in terms of.. . We also get outside speakers. That's also another activity to have people coming outside for school enrichment and benefit from. But they are not particularly well represented by TKC pupils. Yes there is a question that how those people could be involved in term of enrichment. So, yeah, there is a lot work to be done in terms of that.

INT: What can be the reason for this low involvement?

MR ILBERT: I just think that fundementally there is a lack of interest and also there is a probability they need a push by teacher and by parent to go to those things.

INT: Any those activities, do they involve parents?

MR ILBERT: That doesn't really happen.

INT: For home background, how do you see that how does it affect?

MR ILBERT: Parents who more are involved in their child's education are more likely to get a tutor and more likely to help their homework and provide that support. And those students make more progress. And the students that lacking from that support are less likely to making that progress. I think lots of our TKC students fall into the second category where parents want their children do well but maybe don't know how to go about how to make sure that they do well.

INT: What can be done to resolve this?

MR ILBERT: There is something definitely like having more information to communicate with those parents in a more transparent way in terms of how they can provide support and providing them with key information. Although we, I try to put more information on the website and I wonder for those parents whether they are interested or they can an access to the information and the information make sense to them. So yes, obviously one thing would be more parents in to have a meeting which is led by Mr Mahmut and maybe with one of the people from science to provide information and more information are needed to be translated into Turkish also on the website. But still I don't know how much these would make an impact and creating a change.

INT: As a last question maybe. What kind of support do the TKC pupils need to improve their success and their attitude towards science?

MR ILBERT: That's a really difficult question. Okay! The first is the level of support. if the quality of teaching and learning in the department can continually being improved all students will make progress. So as a head of department, just I guess I want is we all sharing a practice doing the right things that we all are marking the books well, we're teaching inspiring lessons and then not just TKC students but for all students will make good progress. And I think with that it comes making high expectations that we are not making any excuses for this group of students not making a good progress because they have issues with literacy then, they are not strong readers and so I think so yes first level of support comes within the classroom but maybe there is something more than that which is school and department we can do with these students. And I don't know this can be after school support and I don't know if that is just general drive doing and improving literacy for whole school. I have a feeling that literacy amongst TKC pupils isn't that good.

INT: Is literacy a barrier for TKC pupils?

MR ILBERT: It is an area, which we need to improve it. Where we are looking at it is literacy is an issue its students where the students are not speaking English as a first language at home and where it is going to be a bigger issue. So the whole school drive and improve literacy it will undoubtly improve the chances of I think TKC students. You know we are doing 20mins reading twice week, next year we hopefully are gonna do it every day. I think the people who benefit most will be the ones who at the lower literacy levels. I think literacy is a barrier because if we look a lot of ours lower ability or middle ability students are from TKC background. You are looking at the one of the biggest barrier is the enjoyment of reading and how well they read and read to understand and there is a lot of work both in the classroom and as whole school. Strategies we need to do to improve literacy for those students.

INT: One more question on interests and attitudes. How do you see students' interest in and attitudes to science?

MR ILBERT: Do you ask in terms of different groups or for students in different year groups?

INT: First I am wondering in general but I also curious about the transition through years.

MR ILBERT: Yeah. I think generally Year 7s are coming very interested in science; they haven't done as much science as they could have done in primary. I think there is an issue with the amount of science they have done in Year 6. Amm. And then I think something happens and I lot of students switch off and they lose their interest by the time they get onto their GCSE science. And you get a smaller group remain really interested In and want to take it their A level. I think we lose a lot of children along the way.

INT: What happens a long the way?

MR ILBERT: I think they find… Amm… there is something about how we teach them. There is something about finding it difficult. There is something about I think we need to make students feel better about being difficult. It doesn't mean 'difficult' means that something you need to give up. Like 'difficult is good' and if it is difficult, there is a challenge to be solved. So yes, they come very enthusiastic in year 7 and if you look at year 10 and 11 as part of your study is about, I think a lot of them we lose, because exams are difficult and maybe the examination system in this country that something we lose something a long the way.

INT: What do you mean with the examination system in this country?

MR ILBERT: This country, in particular is very much focused on how we deliver the exam results and how we measure our successes for how much progress have been made. But I question maybe whether having all that focus on the exam results does that influence, the curriculum as we structure, that maybe does that take something out of the enjoyment of science.

INT: Hmm. So do you think there is too much focus in examination?

MR ILBERT: I don't know what the answers. I know examination is important because it is a way of measuring of progress. But I think this is an underlying factor that turning kids off science, of some certain kids off science.

INT: Thank you very much. We may end it here.

Appendix 14: Sample parent interview

[This is the English translation of the interview transcript, which is originally in Turkish.]

Tanem's interview transcript, Female, Mother of Irmak, Athenaeum School

INT: Thank you very much again for accepting the interview. Let's start. How many years have you been living here?

TANEM: For 16 years.

INT: Did you complete your education here?

TANEM: In fact, I came here to learn language. Then, I met my husband here, I got married and started to live here.

INT: Had you come for a language course?

TANEM: Yeah, I couldn't get into university. I wanted to fill that gap by learning language. I had visa for two years, I hadn't expect it. During that time, I met my husband.

INT: Was he here?

TANEM: Yes, almost for 30 years.

INT: Then, the children were born here. Do you have your family or any relatives here?

TANEM: I have no relatives here. My husband's family is here.

INT: Do you work?

TANEM: No, I don't. For a while I helped my husband. I worked, stopped, worked again. However, I don't work now.

INT: What does your husband do?

TANEM: What would they say? He has a dress shop, Ladies wear, mostly wholesale, mostly to Africa.

INT: It means that the customers are from Africa.

TANEM: Yes, %80-90 in Africa.

INT: How many children do you have?

TANEM: I have three daughters. Irmak, Selin and Ali. Year 9, Year 11 and primary school.

INT: What do you think about your child's school experience?

TANEM: Two of them are already in the same school. A school is close to my house. It is a good school, I'm happy with it. The other two graduated from there with a good grade.

INT: Do you face any difficulties as minority?

TANEM: I don't like the school system here. They regard children as good. They have a standard and if the child is a bit above that British standard they regard as very good. However the child may not be very good. I couldn't care about for the first few years. So, I couldn't notice. They always regarded as good. I didn't like, still I don't. They don't teach much, let them free. However, in the last year, they want you to study horse-like.

INT: Isn't the intensity prorated?

TANEM: I can make a comparison this year. I can compare my younger one with my elder daughters. For example, my younger daughter. I sometimes ask ıf it is difficult for her age. I understand when I compare. However, they leave it to the parents. I look at what they give at school.

INT: Your point saying what they give at school?

TANEM: I mean I look and understand that the standards have been raised.

INT: In proportion to the previous?

TANEM: Yes, previously, I think it was easier. But now, I see that they are in a kind of race, too.

INT: It is a common critic I hear: the marathon begins so early in Turkey.

TANEM: I never like it. When I go to Turkey for holiday, I observe my own cousins. My daughter is Year 11 but they live the same stress every year. I think we don't know the balance. Do we regard much as much, little as little?

INT: Well, maybe! What about the most favourite lessons of the children?

TANEM: My daughter used to love math so much. She got courses for a long time. She graduated from the primary with a good grade but now, she doesn't even want to hear the name.

INT: Why?

TANEM: She is happy that she will not use math when she graduates. She has verbal skills like me. I never liked math. She says that why do I do lessons I will not take? It is so nonsense. If I don't use it for A level, why shall I learn it? The ones who will use shall learn. The ones with verbal skills can choose verbal for a level, too. Why do I waste my time for this?

INT: How are they at science?

TANEM: My elder one likes physics so much. A physics researcher had come. She said a physics professor had come. She loved so much.

INT: Did he or she tell about own research?

TANEM: Very interesting, I don't know what she told, in fact she had told me, she says I'm so forgetful she is right, she said that she advised her to study physics. She loves physics. Not chemistry or biology. She is interested in biology, too. Better than maths.

INT: Yes, I see. What does she love most?

TANEM: Psychology.

INT: What does she want to be?

TANEM: Lawyer.

INT: Are the jobs you see suitable for her the same with the ones she wants?

TANEM: We have an impact on her, I think. I am sorry about that. I wanted to be a lawyer but I couldn't. Neither my husband. He is better than me; he didn't go to university although he won the exam. His is another sob story. He could complete his education under difficult circumstances like me. Both of us wanted to be lawyer. I think we have imposed upon her to be a lawyer since her childhood. My daughter is chatterbox, she can express herself very well. She sees a thing through. We have always said it fits you. She also says you affected me but now she wants too. She says she will be sad if she doesn't become a lawyer.

INT: You mean that you have had an impact upon her to focus on this job but as she has skills compatible with the job, she has adopted, too.

TANEM: Yes!

INT: You say that she is good at physics, too. If she decides to do something in this field, can she manage? What do you think?

TANEM: Yes, she says that I want to be even an astronaut.

INT: You say that you had an impact upon her to be a lawyer but is there any other factor or role model she is affected in this field?

TANEM: No, there isn't any lawyer in the family. However, in Turkey, many people said that she was chatterbox, she could be a lawyer. I think all these affected her.

INT: It means that she agreed with these comments. Do you want her to have a career in the field of science? What do you think?

TANEM: To tell the truth, we may have had an impact upon her as her parents. I don't like science since my childhood. I like math to some degree. In the college years, I liked a bit more. I said this to my teachers, too. I think teachers have a big role on the students to like a course. When I didn't like my teachers, I didn't like the course, either. I observed the same thing on my daughters, too.

INT: Didn't they like their teachers?

TANEM: For example, Irmak came to this school later. Selin is the same, too. There are fifteen in small classes. Ten pupils like, the remaining doesn't.

INT: Dou you think she still doesn't like?

TANEM: Yes. Also, in this school there is no lab. My daughters like lab, learning by experiment so much. They had a lab in the previous school. I think this is a significant factor.

INT: You are right about lab. Many pupils have pointed this.

TANEM: I'm trying to state that the more facilitates in the school the better. Not only reading but to have fun while learning is important, too. I don't like science but I still remember the experiments in the lab. Although I don't remember many about n-my childhood, I still recall the experiments.

INT: Does she share with you what she likes about science or when she learns something new?

TANEM: Of course, although there is not a lab in the school, she tells what she finds interesting. Irmak tells more, not Selin.

INT: Then, she tells and you listen, right?

TANEM: Both her father and I give examples from our own life. Or we talk about what she likes.

INT: You don't like science but are you interested in the jobs like doctor, dentist etc?

TANEM: I always appreciate. In fact, I like medicine. Moreover, I had thought to be a nurse. However, if it doesn't come true.

INT: What do you think about the working circumstances?

TANEM: Medicine is nice according to me. So is teaching. I sometimes tell Selin to be a teacher. She says if I can't be a lawyer, I can be a teacher.

INT: Do you have books or journals about science at home?

TANEM: No, we don't have that kind of resources like journals. I brought once but they didn't have an interest.

INT: Even if you aren't interested as parents, is there anybody in your big family or your social environment who is interested in science?

TANEM: We know somebody familiar. There was something about inventions

INT: Like a fair?

TANEM: Yes, a science fair. We joined but they didn't like. We went to Science Museum. It has a large, different content. We went there twice. They liked so much.

INT: You went with your all family?

TANEM: Yes. Even my little daughter liked there so much. In fact, she liked there most. She is more interested.

INT: Irmak liked there but does she think different afterwards?

TANEM: Yes, she says science is out of her element. You know science has three ummm…

INT: Do you mean physics, chemistry and biology?

TANEM: Yes. All we agree that we love biology. All family. My daughter likes physics but I don't. None of us like chemistry. But she is fond of physics. She says if I hadn't studied in this field, I would have studied physics. She says I love physics. However, she is not interested in chemistry.

INT: In fact, chemistry is experimental. What do you think?

TANEM: Yes. Experiments are nice. For example, my second one said that they had looked into heart in the school. She was attracted. She touches something alive. When they use experiments, they love; I know. But she likes physics.

INT: Does their interest lead them to something else like experiments, researching?

TANEM: No. They are so busy with GCSE. They don't have even a social life.

INT: Has she ever been occupied with something like that?

TANEM: While she was little, yes. Since she started the school, no.

INT: What do you do as a whole family?

TANEM: I like sitting by table as whole family, listening to each other, having a picnic, playing games so much.

INT: Are you occupied with their homework?

TANEM: I can’t do with Irmak anymore. Hers is beyond me. I am busy with the youngest almost every day. The middle one often asks her elder sister for help. But I am occupied in her math. But I wasn’t interested in Irmak while she was little. You don’t know the system with the first child. They always say very well. I understood everything while she was in Year 2. I slept for two years. I learned that there were groups or levels in the system.

INT: How and when did you learn this?

TANEM: While she was in Year 3, I learned that. She said she was in the same group with Cecil. Nobody told me about that kind of grouping.

INT: How often do you go to Turkey?

TANEM: We used to go every year but for 6-7 years, we haven’t been able to go every year.

INT: How do you feel in terms of belonging?

TANEM: I can say that I am sure everybody feels the same; you are neither from here nor from there. Neither we exactly adopt here nor are we adopted. When we go to Turkey, the people there see us as foreigner. What a shame!

INT: A result of living abroad.

TANEM: Yes, your people think that you live a very different life abroad.

INT: What about your plans for the future? Have you settled down in this country?

TANEM: No, I want to leave. But Irmak doesn’t. She says she can’t manage. In fact, I would like her study at university in Turkey.

INT: What does she think?

TANEM: We don’t know about the process. There are foreign students. Do you have any information?

INT: There are exams for foreigner students. They apply with the exam results. But I don’t have updated information. It may have changed. Well. At the moment Irmak is looking for Sixth form College how are the applications going?

TANEM: Well... She wants Woodhouse the most. They say her grades are very good but they put her in the waiting list. They said if she changed subject they could take her.

INT: Does she give up English?

TANEM: No, never.

INT: Which lessons does she think to take?

TANEM: She has already English, psychology. She thinks about politics and sociology.

INT: Is Woodhouse a possibility?

TANEM: Another one is Ashmole but she hasn't received an answer yet from there.

INT: Does she have a special choice as university and department?

TANEM: She wants to study on Criminal. Therefore, she wants to study psychology and law together. There is on in the Centre. He says it is very good at Law.

INT: LSE?

TANEM: Yes, she wants there. If it was to her: Cambridge, Oxford. (Laughing)

INT: Why not?

TANEM: Yes, but I think in a realistic way. I don't say anything to her. If I say, she will be disappointed.

INT: Do you want her to think realistically?

TANEM: Yes.

INT: Do you tell her that directly?

TANEM: I tell but she gets angry with me.

INT: If so, she will most probably study in university here.

TANEM: I thought about Canada. My brother is in Canada. But people say that if she studies in university here and works there, it is better. Education is better in here, they say.

INT: She doesn't think about Turkey, if so?

TANEM: She says she can't manage in Turkey. She is right.

INT: How is her Turkish?

TANEM: She speaks Turkish but when she reads she doesn't understand Turkish like she does in English.

INT: Do you speak Turkish at home?

TANEM: Yes, I have spoken Turkish at home. We connected Turkish TV channels. We took them to Turkish weekend schools. They are good at speaking, a bit good at writing.

INT: Do they watch Turkish TV channels?

TANEM: When we first connected, yes they did. But now they don't watch. They learn something from their Turkish friends in the school.

INT: Irmak will study in university here. Do you see any obstacle?

TANEM: Irmak may give up quickly. I am afraid of this.

INT: Does she lose her motivation?

TANEM: Maybe because of us. When we approach her in a realistic way. While she was in Year 4 or 5, I would say I hadn't expected this grade from her. She remembers and says that you didn't tell me that I could fix it.

INT: Does she accept this?

TANEM: She says she will study in order to prove herself to me. At the beginning, I didn't understand the system but after learned I gave her a hard time. I was panic. Of course the people in Turkey are worse than this. People in here are so easy. We talked with her. Her father and I said that we don't push you but we are behind you. Know what you want.

INT: OK. That's in this way about studying psychology. But she doesn't think of physics anymore, does she?

TANEM: She was hesitated in fact. She couldn't make her mind. But she still loves physics.

INT: Do you think she has an obstacle if she chooses physics?

TANEM: No, I don't think she has. Because she loves it, too.

INT: It is interesting for her to give up although she loves it so much.

TANEM: Yes, when I noticed I was upset. I said we thought it would fit you. But the children ask how much they can earn. She couldn't make her mind for a long time.

She asked for so many times. She talked to Ms. Nilay at school. Then, she decided. She thinks f she can’t do, she will think again.

INT: When she thinks again, will there be any obstacle for her?

TANEM: I think she should go, start and see the environment. She may say yes, that’s it or not.

INT: Who else does she talk about these?

TANEM: We have a few friends who are lawyer. She talked to them. They informed her.

INT: Is there anybody she can talk about science?

TANEM: No, there isn’t.

INT: If there were, would it make a difference?

TANEM: In fact, I think if she saw someone like that professor lady who came last year, she would definitely change her mind. She was so attracted by her. However, she expresses herself very well. Everybody around her thinks these occupations fit her due to her social qualifications.

INT: Thank you very much. Thanks for your time. Lets end this up here. If you have any question, I can answer, I would appreciate to?

TANEM: No, thank you!

Appendix 15: Sample questionnaire conducted in London

Leading education and social research
Institute of Education
University of London

Date:

Dear Student,

Please read this section before you begin

In this questionnaire, I want to understand more what students feel about science. I am asking you for some personal details (such as your name), but this will be used only to see the changes in your answers if I do the survey again next year. The value of the findings depends on honest answers from many students. Of course, participation is voluntary.

We hope you will answer all the questions but if you feel uncomfortable with a particular question, feel free to skip it.

All answers are confidential.

We won't share your answers with your teachers, parents, or anyone else.

Thank you for helping us!

1. About You

a) What is your gender? Female ☐ Male ☐

b) What is your first name? ☐

c) What is your surname? ☐

d) What is your date of birth? DD / MM / YYYY

e) Were you born in the UK? Yes ☐ No ☐

If No, how long have you been living in the UK? ☐

f) Choose one option that best describes your ethnic group or background

White ☐English / Welsh / Scottish / Northern Irish / British ☐Irish ☐Gypsy or Irish Traveller ☐Any other White background, please describe ……….	**Turkish** ☐Mainland Turkish ☐Kurdish Turkish ☐Turkish Cypriot ☐Any other Turkish background, please describe ………
Asian / Asian British ☐Indian ☐Pakistani ☐Bangladeshi ☐Chinese ☐Any other Asian background, please describe ………	**Mixed / Multiple ethnic groups** ☐Turkish and White ☐Turkish and Black Caribbean ☐Turkish and Black African ☐Turkish and Asian ☐Any other Mixed / Multiple ethnic background, please describe ……….
Black / African / Caribbean / Black British ☐African ☐Caribbean ☐Any other Black / African / Caribbean background, please describe ………	**Other ethnic group** ☐Arab ☐Any other ethnic group, please describe ………..

2. About Your Family

a) How long have you parents been living in the UK?

Less than 5 years☐ 5-10 years☐ 10-20 years☐ More than 20 years☐

b) What are your parents'/carers' highest level of education	Mother/Carer 1	Father/Carer 2
Primary school	☐	☐
Secondary school	☐	☐
High school/College	☐	☐
University	☐	☐
Postgraduate (e.g. Master, PhD, PGCE)	☐	☐

	Mother/Carer 1	Father/Carer 2
c) What are your parents'/carers' occupations (jobs)?		

(for example: teacher, driver, housewife, unemployed)		

	Strongly Agree	Agree	Neutral/ Neither	Disagree	Strongly Disagree
d) My mother/carer 1 can speak, read and write in English comfortably.	☐	☐	☐	☐	☐
e) My father/carer 2 can speak, read and write in English comfortably.	☐	☐	☐	☐	☐

f) Which language do you prefer when you speak to your mother/carer 1?

g) Which language do you prefer when you speak to your father/carer 2?

h) Which language do you prefer when you speak to any brothers and sisters?

i) How many brothers and sister do you have?

j) Can you fill the table below for your sisters and brothers?

	Sibling 1	Sibling 2	Sibling 3	Sibling 4	Sibling 5	More
Age						
Gender (*Male* or *Female*)						
Is he/she a student? (*Yes* or *No*)						
If *Yes*, in which year/level?						
If *No*, what does he/she do?						

k) What is your postcode (e.g. N14 7AB)?

l) Where do you currently live? (pick one)

☐ In a House/Flat owned by my parents/carers

☐ In a House/Flat rented (tenanted) by my parents/carers

☐ In a Council house/flat

m) Which channels/programmes do you watch on TV?

Mainly British☐ Some British-Some Turkish☐ Mainly Turkish☐

n) Which channels/programmes do the rest of your family watch on TV?

Mainly British☐ Some British-Some Turkish☐ Mainly Turkish☐

3. You in the future

	Strongly Agree	Agree	Neutral /Neither	Disagree	Strongly Disagree
a) I would like to study more science in the future.	☐	☐	☐	☐	☐
b) I would like to become a scientist.	☐	☐	☐	☐	☐
c) I would like to have a job that uses science.	☐	☐	☐	☐	☐
d) I would like to work in science.	☐	☐	☐	☐	☐
e) I think I could be a good scientist one day.	☐	☐	☐	☐	☐
f) I would like to work in engineering.	☐	☐	☐	☐	☐
g) I would like to be an inventor.	☐	☐	☐	☐	☐

4. School science

	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
a) We learn interesting things in science lessons.	☐	☐	☐	☐	☐
b) I look forward to my science lessons.	☐	☐	☐	☐	☐
c) Science lessons are exciting.	☐	☐	☐	☐	☐
d) I would enjoy school more if there were <u>no</u> science lessons.	☐	☐	☐	☐	☐
e) Studying science is useful for getting a good job in the future.	☐	☐	☐	☐	☐
f) School should have more science lessons each week.	☐	☐	☐	☐	☐

5. You and science

	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
a) I do well in science.	☐	☐	☐	☐	☐
b) I find science difficult.	☐	☐	☐	☐	☐
c) I am just not good at science.	☐	☐	☐	☐	☐
d) I learn things quickly in my science lessons.	☐	☐	☐	☐	☐
e) Science is easy for me.	☐	☐	☐	☐	☐
f) No matter how hard I try I cannot understand science.	☐	☐	☐	☐	☐

6. Your interests

	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
a) I would like to visit a museum to see dinosaur bones.	☐	☐	☐	☐	☐
b) I would enjoy collecting leaves, rocks, bugs or butterflies etc. from the outdoors.	☐	☐	☐	☐	☐
c) I would enjoy reading science magazines and stories	☐	☐	☐	☐	☐
d) I would enjoy making model airplanes, boats, rockets and houses.	☐	☐	☐	☐	☐
e) I would enjoy experimenting with making yoghurt, butter and cheese.	☐	☐	☐	☐	☐

7. Your Activities (part 1)

Outside of school, how often do you:

	Not at all	Less than once a month	Once or twice a month	Once a week	More than once a week
a) Read a book or magazine about science?	☐	☐	☐	☐	☐
b) Visit web sites about science?	☐	☐	☐	☐	☐
c) Watch TV programmes about science or nature?	☐	☐	☐	☐	☐

8. Your Activities (part 2) In the past 12 months, outside of school, have you ever:	**YES**	**NO**
a) Visited a science museum with your parents?	☐	☐
b) Worked on a science homework together with your parents?	☐	☐
c) Attended a science fair with your parents?	☐	☐
d) Used a special science equipment (telescope, microscope, chemistry set, etc.) at home?	☐	☐
e) Watched a science-related programme or movie with your family members or relatives?	☐	☐
f) Taken things apart with your parents (like toys, motors, computers, toasters)?	☐	☐
g) Received a science-related gift from your family members or relatives (e.g. toy, experiment kit)?	☐	☐
h) Received a science magazine or science-related book from your family members or relatives?	☐	☐

9. Your parents/carers (part 1)

	Strongly Agree	Agree	Neutral /Neither	Disagree	Strongly Disagree
a) My parents/carers think science is interesting.	☐	☐	☐	☐	☐
b) My parents/carers would be happy if I became a scientist when I grow up.	☐	☐	☐	☐	☐
c) My parents/carers think it is important for me to learn science.	☐	☐	☐	☐	☐

10. Your parents/carers (part2)

	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
a) My parents/carers want me to go to university.	☐	☐	☐	☐	☐
b) My parents/carers want me to make a lot of money when I grow up.	☐	☐	☐	☐	☐

	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
c) It is important to my parents/carers that I get good marks in school.	☐	☐	☐	☐	☐
d) My parents/carers think it is more important for me to get married than to have a career.	☐	☐	☐	☐	☐

11. Your parents/carers (part3)	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
a) My parents/carers know how well I'm doing in school.	☐	☐	☐	☐	☐
b) My parents/carers always attend parents' evenings at school.	☐	☐	☐	☐	☐
c) My parents/carers know my schoolteachers very well.	☐	☐	☐	☐	☐
d) My parents/carers help me doing my homework.	☐	☐	☐	☐	☐
e) My parents/carers ask detailed questions about my lessons at school.	☐	☐	☐	☐	☐

12. Your classmates ***Note: It is your perception, do not ask your classmates!***	None	Less than half	Half of the class	More than half	All
a) How many of your classmates like science?	☐	☐	☐	☐	☐
b) How many of your classmates think science is cool?	☐	☐	☐	☐	☐

13. Scientists	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
a) Scientists and people who work in science can make a difference in the world.	☐	☐	☐	☐	☐
b) Scientists don't have other interests.	☐	☐	☐	☐	☐
c) Scientists and people who work in science are odd.	☐	☐	☐	☐	☐
d) Scientists can make a lot of money.	☐	☐	☐	☐	☐
e) Scientists don't interact with other people much.	☐	☐	☐	☐	☐
f) Scientists can't be religious.	☐	☐	☐	☐	☐
g) Scientists have exciting jobs.	☐	☐	☐	☐	☐
h) Scientists are respected by other people.	☐	☐	☐	☐	☐

14. More about You (Part 2)

a) How many times have you visited a Museum, Historical site or Art Gallery in the past 12 months?

b) How many times have you attended a Play, Concert or a Live sho[illegible] months?

c) How many hours do you spend in a week in cultural lessons/activities outside of school (music, art, dance, and language)?

d) How many hours do you spend in a week reading?

15. Your Future Job How interested are YOU in having a job like these someday? (Mark one in each row)	**Very interested**	**Somewhat interested**	**Not interested**
Life Scientist (Biologist, Zoologist, Ecologist, etc.)	☐	☐	☐
Physical Scientist (Chemist, Physicist, Astronomer, etc)	☐	☐	☐
Doctor, Veterinarian, Dentist	☐	☐	☐
Nurse	☐	☐	☐
Physiotherapist	☐	☐	☐
Dental Hygienist	☐	☐	☐
Lab Technician	☐	☐	☐
Engineer	☐	☐	☐
Computer Programmer	☐	☐	☐
Website Designer	☐	☐	☐
Psychologist	☐	☐	☐
Science Teacher	☐	☐	☐
Lawyer	☐	☐	☐
Businessperson	☐	☐	☐
Journalist	☐	☐	☐
Architect, Interior Designer	☐	☐	☐
Other jobs you are very interested in: ____________ ____________			

16. More about You (Part 3)

	Strongly Agree	**Agree**	**Neutral / Neither**	**Disagree**	**Strongly Disagree**
a) My parents encourage me to make my own decisions about my future.	☐	☐	☐	☐	☐
b) It is my own personal decision which courses to take at school when there is a choice.	☐	☐	☐	☐	☐
c) At home, I decide for myself when to study and when to watch TV or play games.	☐	☐	☐	☐	☐

17. More about You (Part 4)	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
a) If I really like a toy and want to see the parts inside it, I can take it apart easily.	☐	☐	☐	☐	☐
b) If I want, I can undertake an experiment during a science class to a high standard.	☐	☐	☐	☐	☐
c) When I learn an interesting science topic at school, I can learn much more about it at home.	☐	☐	☐	☐	☐
d) If I decide to become a scientist or have a science-related job in the future, I am sure I will be very good at it.	☐	☐	☐	☐	☐

18. More about You (Part 5) How much do you agree or disagree with the following statements about your ethnic background? (Mark one in each row)	Strongly Agree	Agree	Neutral / Neither	Disagree	Strongly Disagree
a) I take part in cultural practices of my ethnic background, such as special food, dance, music or customs.	☐	☐	☐	☐	☐
b) I have a clear sense of my ethnic background and what it means for me.	☐	☐	☐	☐	☐
c) I prefer organizations or social groups that include mostly people who share my ethnic background.	☐	☐	☐	☐	☐
d) It is important that my role model(s) or mentor(s) share my ethnic background.	☐	☐	☐	☐	☐
e) Most of my friends share my ethnic background.	☐	☐	☐	☐	☐
f) People who share my ethnic background have trouble getting jobs in science in this country.					
g) People of my ethnic background are well represented in science in this country.	☐	☐	☐	☐	☐

19. More about You (Part 6)

Think about the kind of person you are (your characteristics, your likes and dislikes, etc.). How important is each of the following to making you who you are?

(Mark one in each row)

	Very important	Somewhat important	Not important
Ethnic background	☐	☐	☐
Gender	☐	☐	☐
Religion	☐	☐	☐
Interests (sports, music, drama, etc.)	☐	☐	☐
Friendships	☐	☐	☐
Romantic relationships	☐	☐	☐
Family relationships	☐	☐	☐
Other students at school	☐	☐	☐
Media images (television, movies, magazines, etc.)	☐	☐	☐
Grades in school	☐	☐	☐
Things you're good at (sports, music, drama, etc.)	☐	☐	☐
Physical appearance	☐	☐	☐
Personality traits (funny, opinionated, kind, etc.)	☐	☐	☐
Goals for the future	☐	☐	☐

20. People you know

Do you know anyone in person who has the following jobs?

	YES	NO	I'm not sure
Scientist (Biologist, Zoologist, Chemist, Physicist, Astronomer, etc.)	☐	☐	☐
Doctor, Veterinarian, Dentist	☐	☐	☐
Nurse	☐	☐	☐
Physiotherapist	☐	☐	☐
Dental Hygienist	☐	☐	☐
Lab Technician	☐	☐	☐
Engineer	☐	☐	☐
Computer Programmer	☐	☐	☐
Website Designer	☐	☐	☐
Psychologist	☐	☐	☐
Science Teacher	☐	☐	☐
Lawyer	☐	☐	☐
Businessperson	☐	☐	☐
Journalist	☐	☐	☐
Architect, Interior Designer	☐	☐	☐