‘The sun does not have electricity’: using photo elicitation and cultural models to explore secondary students’ perspectives of connecting science with the real world

A thesis submitted to The University of Manchester for the degree of Doctor of Philosophy in the Faculty of Humanities

2020
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<tr>
<td>ESRC</td>
<td>Economic and Social Research Council</td>
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<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
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<td>Ofsted</td>
<td>Office for Standards in Education</td>
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<td>PEI</td>
<td>Photo Elicitation Interview</td>
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<td>TISME</td>
<td>Targeted Initiative on Science and Mathematics Education</td>
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<td>UK</td>
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Abstract

Recent debates in science education use the term ‘relevance’ frequently and in various ways. However, the meaning and significance of the term continues to be problematic, from the angle of both science education research and also science teaching. Relevance has been investigated in terms of young people’s participation and engagement in science, but the instruments employed have not been particularly effective for learning about young people’s perspectives. Moreover, their perspectives concerning science and their relationship to science has so far received little attention in the academic literature.

This thesis focused on exploring secondary school students’ perspectives on connecting science with the real world based on a photograph taken by them via photo-elicitation methods. The research questions were the following: (1) How do secondary school students describe their experiences in seeking the real world out of school? (2) How do students make meaning of their experiences to describe how science is connected and disconnected to the real world?

The participants were a group of 16 pupils (13-15 years old) who attended secondary school in England. They were from different backgrounds, attainment level and attitudes toward science. Each participant was provided with a disposable camera and asked to take a series of photographs to demonstrate how they see science connected and disconnected to the real world. Discussions then took place with participants in pairs, based on the photographs that they had each taken. This approach made it possible to attend carefully to the meanings that science had for these young people, without the whole process being dominated by words. These interview data were analysed using NVivo 11 software, alongside the use of photographs to inform and illustrate the analysis. Several themes were generated to reflect what was important to participants. In addition, a case study approach was used to allow more in-depth multi-faceted explorations of complex issues in young people’s perspectives toward science.

The results of the study have revealed how differently pupils think about science from each other and from what the educator might think and assume. The study allowed young people the opportunity to position themselves in relation to science both in and out of school, linking to their agency as they showed how, for them, science was connected and disconnected to...
everyday life. The study suggests ways for teachers and curriculum developers to pay more
attention to students’ backgrounds and perceptions, and to design scientific instructional
approaches that better meet students’ needs for a meaningful engagement with science.

The thesis also provides the science community with a novel way to access young people
perceptions in an age-appropriate manner. Applying photography in this way proved to
be an appropriate and entertaining way for students to communicate their perspectives. The
photo elicitation technique can help the science teacher, curriculum developer and the whole
science education community to identify gaps in ways in ways of teaching, also improve and
strengthen the relationship between science teacher and student. Further work is necessary to
apply these photography techniques better to school routines and to adapt these tools to
different context.
Declaration of Original Contribution

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This work is dedicated to everyone who goes through a mental illness battle in silence and shows up strong and happy, please seek help and believe in yourself; I won my battle and the proof is in your hands.
Acknowledgment

Words will never express my deepest appreciation to my supervisor Andy. Thank you for all your help and support through this journey. Thank you for being the most understandable, supportive supervisor I ever had. I was on edge most of the time and you kept encouraging me. You made me believe in myself and in my work. It is through your support and guidance that the thesis remained engaging and exciting.

I would like to give a huge thanks to the best university staff, Liam and Debbie, for their professional work and for kindly answering all of my ‘where and how’ emails. I would like to give thanks, also, to Jess, who was the first one who made me see the light at the end of the tunnel of this journey and the one who inspired me to remain strong and patient with my health issues.

I would like to thank my family for their ultimate support. Special thanks to my brother, Mohammed; I would never have made it this far without you. And special thanks also to my sister, Rana, you are my soulmate, thanks for calling me 24/7 to check on me and always knowing how to make me laugh. Also, I would like to thank my friends Hanaa, Nada, Abdul Rahman and Sultana for their love and support. Thank you for always being here, especially in my darkest times. I am so lucky to have you in my life.

Finally, I would like to thank the young people who took part in the research. You gave up your time and shared your experiences. And I would also like to thank the social workers who supported me in recruiting the sample for this research and facilitated me meeting with the participants. I am hoping this study will go on to inform people about what was important to you as a participant group and that others get to learn as much as I have through hearing what you said and seeing what you showed me.
CHAPTER 1

Introduction

It is true that science is not always popular among secondary students, according to the many studies that have been done on this matter; e.g. (Dillon, 2009, Hofstein et al., 2011, Osborne et al., 2003); and Stuckey et al. (2013). One reason for this that has been mentioned quite often is that young people claim that science is not relevant to their lives (Aschbacher et al., 2010, Jenkins and Nelson, 2005, Stuckey et al., 2013). As a result of this claim, all eyes have been directed towards the science teachers. Science teachers are required to make school science more relevant to their students’ lives (Newton, 1988, Holbrook and Rannikmae, 2009). The meaning of the word ‘relevant’, however, is still unclear. The meaning of the term ‘relevance’ remains to be confirmed from the angle of scientific research, science teaching and students’ perspectives. This study evolved from the researcher’s own experience as a science teacher, one who has been asked to make science lessons more relevant without any clear guidance or prior training. The fact that there is comparatively little previous research that can provide an answer as to how young people perceive the connection between science and their lives inspired this study and the investigator’s desire to explore young people’s perspectives on this relationship.

In general, students and science teachers are on the front line of the debate surrounding poor science education outcomes. The science education community has assumed that teaching methods must be updated. They are prone to focusing on encouraging students to participate more in science classes and activities. However the main focus, as always, is the exam results. From my perspective, it seems like no one believes that the science curriculum is not relevant to young people’s lives. The commonly-held view is that the science curriculum is not the problem, and that we rather need to fix the teaching methods and find ways to engage students more.

I am a science teacher, and my mother is an art teacher, and we both have the same problem: the heads of school departments, the evaluators and the students’ families are frequently question or implicitly blame us for our students’ attainment levels. In the context of science, if you read any article discussing this problem, the writer almost always blame the education
system, the school, the teachers and the teaching methods; however, little emphasis is paid to students’ voices. When young people abandon science studies, they leave the science teachers facing difficulty. Almost all fingers are pointed towards science teachers; their strategies and methods are the first thing to be blamed and investigated. As an example Lacour and Tissington (2011) state that teachers must work harder to comprehend students’ backgrounds and establish links between their homes and the schools they attend. Teachers, therefore, are always the first people to be told to change and the students seem to be the last people to be considered and involved.

When we discuss the word ‘relevance’, there are a lot of ideas and topics that can be considered to interpret its meaning. In the science education community, it is not a secret that many students are not interested in studying science. The extensive literature investigating this topic leaves us to wonder why this is the case. If students see science as irrelevant, this may indicate that they have their own view of the relevance of science to their lives. If so, how do they see the relationship between science and the real world? Is it possible that young people are not interested in science because they see science as detached from the real world, the world that they live in? If so, how do young people picture the real world? To answer these questions, we decided not to use traditional methods, such as interviews and surveys; we instead asked young people to take pictures representing how they see the relevance and irrelevance of science to their lives with disposable cameras. By investigating these sorts of questions, we were hoping to discover the missing piece of the puzzle of why science is not relevant to young people.

1.1. Statement of Problem

The term ‘relevance’ is used to refer to many things in science education, such as the students’ interest (Childs, 2006, Ramsden, 1998) and how to make everyday life experiences meaningful for individuals and society. Relevance also describes how well young people perceive the worth of understanding the real world in the context of their education (Gilbert, 2006, King and Ritchie, 2012, Lyons, 2006a, Mandler et al., 2012). Synonyms of the term ‘relevance’ as it is used in this research include importance, usefulness and need (Keller, 1983, Simon and Amos, 2011).

This research seeks to know how science can be seen as relevant or irrelevant from young people’s perspectives. Also, this research attempts to understand young people’s perspectives on the connection between science and their lives. Therefore, this study used an evolving

1.2. Purpose of the Study
The purpose of this study is to explore young people’s views on the connection between science and their everyday lives.

1.3. Research Questions
To elicit responses from secondary school students about their perspectives on science as it relates to the term ‘the real world’, the following research questions guided this study:

1. How do secondary school students describe their understanding of the real world?
2. How do students make meaning of their experiences to describe how science is connected to and disconnected from the real world?

1.4. Overview of Design, Methods, and Analysis
The main method adopted in this study is photo-elicitation. Other approaches were considered, such as interviews, focus groups and learning walks. However, the methodology employed had to have certain characteristics: enabling young people to speak and to bring their worldview to life for the researcher; creating a context in which young people’s assumptions and ideas could be communicated effectively; and achieving this with young people from diverse ethnic backgrounds. Photo elicitation is a participant-generated methodology that introduces photographs into the research process based on ‘assumptions about the role and utility of photographs in promoting reflections that words alone cannot’ (Clark-Ibáñez, 2007). More specifically, the participants in this study were given two weeks, a disposal camera and photo guidance and were set off to capture their experience in photos. The participants were asked to be prepared to talk about selected visual images before engaging in the photo-elicitation interview (Wiles et al., 2011). The photo-elicitation interview occurred after the participants took their photographs (Harper, 2002, Rose, 2016). The interviews not only prompted more information, but also evoked different and more personal narratives (Harper, 2002). Photo-
elicitation offers richer, more insightful narratives than would be possible using traditional methods, and offered participants the chance to lead the methodological process (Guillemin and Drew, 2010, Harper, 1986, Harper, 2002, Pink, 2007, Mitchell, 2011, Ford et al., 2017). This approach is embedded in the interpretivist epistemology, because ‘both the photographer and the viewer of the photograph construct its meaning because both bring their social position, personality, and personal history to the interpretive act’ (Loeffler, 2004b, para. 7).

Data was generated through three sources: (a) data elicited from participant-generated photographs, (b) data collected from the photo-elicitation interview about the meanings behind the photographs and (c) a field diary in Arabic language used to generate post-interview notes. The field instrument was used to conduct the ongoing data analysis. The instrument was also used as a means of reflexivity to help the researcher note any biases that may have affected the research process. As a way of keeping the participants’ voices in focus, in vivo and theoretical coding were employed as data analysis techniques.

1.5. Theoretical Framework

The theories that I apply to my research are cultural models and cross-cultural science education. Cultural models constitute the unspoken concepts we embrace about the nature of the world. Cultural models are shared; not universally, but socially, and largely through language, through the images, metaphors, schemas or storylines that guide an individual’s mind, social and cultural tools and mediating devices (Gee, 2004). Cultural models are a powerful way of conceptualising the different positions occupied by teachers and students in science education. As Aikenhead (1996, 1998) notes, students who studying science are members of the school science culture, as they position themselves within the norms, values, beliefs, expectations and everyday actions of that world. This change involves the movement between the culture of their lives outside school, which include family, friends and society, and the culture of school science. These changes can be highly problematic, because the school science culture can be so different from the students’ own cultures and other cultural groups (Aikenhead, 1996, Aikenhead, 1998, Aikenhead, 2001). Therefore, ‘border crossing into the subculture of science needs to be managed’ (Aikenhead and Jegede, 1999).

The inability to effectively cross the borders into the world of school science may result in several difficulties related to learning. Their cultural model of achievement in science

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1 Writing the field diary in Arabic – my first language – allowed me to record my immediate feelings and observations more directly.
education is very different from that assumed by curriculum developers, for example Larson (1995) revealed some of the difficulties that she faced during her investigation of the unintended curricula in an American secondary school. She claimed that the students were able to pass all of the assessments and complete all of the compulsory work without ‘meaningful learning’. This achievement resulted from the students adopting certain strategies, which Larson (1995) called ‘Fatima’s Rules’, named after one of the participants in her project. This approach works when the student uses certain memorisation skills and shows communicative competence rather than by understanding and being cognitively engaged. Students activate Fatima’s Rules when they face problems in the transition between the world of school science and other worlds, I will return to this point in Chapter 3. Larson (1995) was looking into the culture of school science and the cultures outside the school. In my research, I will try to understand how students see the world that they inhabit, and how they describe the connections between science and that world.

With the prevalence of faking engagement and with educators primarily being worried about assessment results, science will remain irrelevant to students’ lives. According to Holbrook and Rannikmae (2009), Gilbert (2006) and Dillon (2016) this could be because many students feel that science is irrelevant to their own lives and their communities. As stated by the UK Commission for Employment & Skills, 43 per cent of science, technology, engineering and maths (STEM) jobs are hard to fill. This is mostly due to a deficiency of candidates with the required skills and experience. One of the main root causes of this deficiency is the growing skills’ gap in education, from primary and secondary school through to university and workplace training (‘UK Commission for Employment and Skills - GOV.UK’, 2018). Exploring the students’ views on the connection between science and the real world may aid in defining this gap and identifying how to assist and guide students to genuinely engage with the discipline.

1.6. Significance of the Study

The results of this study may provide an opportunity to improve our communication skills, reach out to students and gain more insight into their lives. It may help us not to assume how young people perceive science and how they should respond to it without communicating with them, and also to stop blaming their teachers, or students’ level of intelligence and their lives outside school. It is an invitation to listen to young people’s voices, regardless of their backgrounds, attitudes towards science or exam results – and to really listen to them.
The results of this study will show that the responsibility should not only fall on the science teachers or students. The entire hierarchy of education is involved and responsible; they all have their own influence on the educational outcomes. I believe that this is the first piece of extended research present young people’s voices and related photos regarding their understanding of and views on science education. The results of this research were eye-opening for me personally, and will change the way that I teach science in the future. Moreover, the advantage of using photo-elicitation methodology was stimulated self-reflection by young people: engaging the participants in critical thinking about their experiences in both visual and narrative forms, as well as asking them to take photos and decide on particular ones to share in the photo-elicitation interviews. The empirical process at the heart of this study may also help to meet the challenges that are presented by with young people’s cultural models and help them to cross the border between home life and school science successfully.

1.7. Limitations of the Study

Several limitations of the study’s design may have influenced the understanding of the findings of the study. Firstly, these findings relate directly only to a small sample of young people, all female, in one secondary school. The group is representative of a much wider population of young people in some ways – age, attending state school. In other ways they are not representative – boys are not included, neither are young people with significant disabilities, and the proportion from BAME backgrounds, and with EAL, is much higher than average. The socio-cultural theoretical framework suggests that nevertheless the findings will have much wider resonance, but that is something that others will have to judge as they bring their experience into relationship with the findings. (Theoretical generalisation, naturalistic generalisation, transferability, analytical generalizability). Secondly, the researcher could not anticipate or predict occurrences that might have disturbed or impeded participants’ capacity to take photos or their interpretations during the photo-elicitation interview. Even though this study has generated rich understandings from the field, the researcher notes a number of limitations of the findings. First, there is the issue of sampling. This study recruited a small number of informants to generate data and subsequent findings. Given the small sample size, the findings are not immediately generalisable to other settings (Patton, 2002). Future studies could build up upon findings from this study to expand the scale by involving more participants or enlarging the institutions involved. Researchers who wish to further this research could also consider different experiences between ethnic, racial groups and male and female students,
since this study only involved female students. Second, future researchers could use the field notes to more fully investigate a particular theme, such as visualisation, in order to extend the cultural models theory or aid in the development of a new theory. Third, the photographs may have permitted abundant opportunities for participants to gather many images and these photos provided an overabundance of opportunities for reflections, however we asked participants to focus on just one photo for each statement. Even though the researcher restricted the photo-elicitation interview to a discussion of the content of the photos only, the photos proved too numerous to discuss in an interview limited to 30 minutes.

1.8. Locating Myself as the Researcher

I always introduce myself as a science teacher, even though I did my bachelor’s degree in science and mathematics education. I am more interested in science than math, so I chose to teach science. I taught science for four years, and then received a scholarship to start my study abroad journey to achieve higher degrees in science. I was supposed to do a master’s degree in biology, but I could not resist my interest in teaching science. I ended up obtaining two master’s degrees in education; both of them are in science education.

From my perspective, teaching science has three points, like a triangle: the science curriculum, the science teacher and the student. My first master’s thesis was about exploring and analysing the new science curriculum content in Saudi Arabia, because I always feel that our voices as science teachers are not heard. And as I mentioned before, we are the first to be blamed for students’ poor attainment levels in science, which is why I decided to explore the new science curriculum content. From my perspective, based on my experience as a science teacher, teachers usually blame the curriculum structure and content. My research on the science curriculum was significant; the main finding was that the curriculum has a lot of activities for the classroom and lab, but these were not possible in most schools. Moreover, curriculum creators apparently do not consider the variety of young people’s abilities in class. There is also a lack of lab equipment and a need for teacher development programs and training.

The outcomes of this first attempt at master’s research made me realise the pressure and stress science teachers face in implementing new science curricula. I decided to explore the level of satisfaction of science teachers in terms of implementing new science curricula. The main finding was that teachers do not receive any training program before implementing new curricula. As well, the ministry of education did not offer any resources or guidance
whatsoever. As a result of exploring these two aspects of science teaching, science content and science teachers, I have become more interested in knowing about the students. Young people becoming less interested in science and not considering it as a future career path are global problems.

When teaching science, it is reasonable to note that some young people are not interested in doing science. Every individual has his or her own way of seeing science. Some students may think science is boring; others might think it is hard and only for brainy people. There is a massive amount of ongoing research about how to make science more interesting and how to encourage young people to pursue science for the future. The outcomes of this research, in my opinion, are steady, but there have been no big conclusions. All of the outcomes lead us to the same results. For example, some research advises that we need to engage students’ families and communities, or do more informal activities like camping, clubs etc. As well, some studies suggest exploring young people’s background, their science capital and the cultural capital they have. All of these efforts are undertaken in the hopes of improving students’ attainment levels in science, and also in the hope that young people may become more engaged in science and start to consider pursuing it in the future.

However, much of this research appears to rest on assumptions about young people’s perspectives and responses – about their lived experience of science. This research taught me that, even though I have personally worked in science education for almost 14 years, I do not understand what my students’ unspoken struggles are, or how they view science. I always thought I knew what they were facing, but I never asked. I believe our way of focusing too much on the students’ grades is akin to implicitly saying that science is about achieving a high degree and that science is no more than a subject at school; one that is only for the smart students who can achieve high grades. This research journey showed me that even though I consider myself a very engaging science teacher, I do not, in fact, know much about my students’ perspectives on science and that I measured myself and my students based on my own cultural models, and on the final exam results, too.

All of my research has been dedicated to helping myself and other science teachers to teach science better. This study contributes to the body of knowledge about young people conceptions and understandings of science. Also provide one of the few insight investigation into young people hidden voice and the way of thinking and viewing science.
1.9. Thesis Overview

This thesis is organised into eight chapters. Chapter One is the introduction; it is about the statement of the problem, research questions and the significance of the study. The chapter ends with the thesis overview. Chapter Two is the literature review; this chapter provides a brief history of the relevance of science education and offers a critique of the research approaches used to investigate how the word relevance has evolved to date. The chapter also presents two big projects that are still ongoing in science education: ASPIRE and science capital in science education. The term ‘student voices’ is also discussed briefly. The argument presented concludes that there is a lack of qualitative studies investigating young people’s perspectives in relation to science, and why a qualitative technique called photo-elicitation interviews warrants application in this field. Chapter Three presents the theoretical framework. The chapter will explore the meaning of ‘culture’ in general and in relation to the context of science specifically. Chapter Three will then present the cultural models theory and the border crossing theory. Chapter Four details the methods used in this study. Chapter Four examines the photo-elicitation interview method from the perspective of cultural models and describes the procedures used to implement photo-elicitation interviews within the context of the school setting for the study reported here.

Chapter Five presents the results of the study and focuses on the results generated from the photo-elicitation interviews. It is organised around the dominant themes emphasised by students, such as ‘the real world is nature’, ‘everything is connected’ and ‘the sky’. Throughout this chapter, participants’ quotes and statements are reproduced verbatim to substantiate the interpretations made and to maintain the ‘voices’ of the students. At the end of each theme, a short discussion compares the results generated from the interviews and photo statements.

Chapter six presents five Pen Portraits, each of which will start by introducing the participant’s background, attainment level and the research observations from the observation phase. Chapter Seven forms the basis of the discussion at the core of the thesis. In Chapter Seven, the ways in which the students in this study experienced science in the real world are discussed within the context of the cultural model theory, the border crossing theory and in science capital literature. This discussion is presented using the research questions and the photo statement questions, which have been organised in tables, and which are followed by the argument. The thesis comes in to a close in chapter eight by further identifying the limitations of the study, sharing recommendations for practitioners and researchers and offering concluding remarks.
CHAPTER 2

Literature Review

This chapter includes the literature review related to the term ‘relevance’ in a science education context. Moreover, the chapter will present scholarly efforts to make science more relevant and will explore how, in each new decade, students try to learn and correct the mistakes that have come before them. There are three sections in this chapter: the first section discusses the historical background of the term ‘relevance’ and its evolving role in science education. In the second section, one of the most important scientific projects in the science education community in the UK, ASPIRE, will be presented. Along with the science capital, a theory emerges from ASPIRE data. In the last section, I will present previous studies about the philosophy of exploring student’s voices, including a review of studies on science education.

2.1. Introduction

For over 40 years, the term ‘relevance’ has been debated in the science education community. The extent of the term ‘relevance’ in science education and curriculum reform has no definite boundaries. In this study, we used the term ‘relevance’ and the term ‘connection’ to refer to the same things, especially since English is the second language of most the participants. We could not find a clear explanation of the meaning of the term ‘relevance’ in the science education community these days. The idea for this study come out of a desire to see whether young people see science as relevant or connected to their lives.

2.2. Searching for the words ‘relevance’ or ‘connection’ in relation to science education

If you decided to search for the phrases ‘connection in science education’ and ‘relevance in science education’ online, the first result to show would be the Relevance Of Science Education Survey (ROSE). The survey was created by (Schreiner and Sjøberg, 2004). That survey, however, mainly focused on student interest, although the authors themselves claimed that they used the term ‘relevance’ theoretically in a contextual relevance manner in order to help them choose potential themes. The authors of ROSE also stated that they do not have a clear
definition of the term relevance and do not use the term interchangeably with any other words (Schreiner and Sjøberg, 2004). I used part of this survey as measurement for choosing potential participants for this study. Many other researchers view the term relevance as more or less interchangeable with ‘interest’, e.g. Levitt (2002). The terms interest and relevance seem to have an interrelated interpretation consistently; however, they are not identical ideas (Levitt, 2002). There is a misunderstanding that interest is equalled to enjoyment (Jack and Lin, 2018, Ainley and Ainley, 2011). In their work, Potvin and Hasni (2014) try to explain the difference between interest and interest in relation to science. Potvin and Hasni (2014) argue that enjoyment can happen for many reasons and interest is one of them. Indeed, some topics in science education can be relevant and connected to student life without being interesting. Until today, young people were not interested in or motivated by studying science or pursuing careers in science in the future. There is no clear single reason for that. Studies show that one common reason was that young people see science as irrelevant or disconnected from their lives and from the world around them in general (Dillon, 2009, Holbrook, 2008, Gilbert, 2006). Some research has also stated that young people are insufficiently interested in science or are not motivated to pursue science (Jenkins and Nelson, 2005, Osborne et al., 2003). These findings may be surprising to some and not make sense, especially since scientific advancements have developed rapidly over the years and, as such, school science curriculums are becoming more and more exciting and well-presented. Moreover, the school system, school buildings and the quality of life outside of school have also improved in developed countries. As well, there are many new and still-developing programs available for teachers. There are also some activities for young people available these days both inside and outside of school that are somehow related to science. Unfortunately, however, the number of young people who choose a career in science is still decreasing in the UK (White, 2017).

An explanation of how science education can be made relevant is lacking both in terms of research and curriculum development (Stuckey et al., 2013). A paper by Stuckey et al. (2013) mentioned three roles in society that have a significant influence over our understanding of the term ‘relevance’ in science education. He believed that the term relevance is not limited to educational research and practice; this term is often affected by stakeholders both inside and outside of educational circles. He suggests that scientists working in academia, educational policymakers and business decision-makers contribute to forming current interpretations of ‘relevance’ in science. Stuckey et al. (2013) suggested that there is no doubt that the views and goals of every one of those stakeholders strongly influence the way teaching and learning in
science should be done. It is surprising that the views and perspectives of the target population, which is young people, are not mentioned or considered. By not considering young people’s perspectives, there is a concern that teachers do not know how to make science relevant to young people’s lives. From my perspective, we cannot assume that the current model functions in the best possible manner, because we are relying only on the results of studies and the viewpoints of researchers. There are a lot of questions that must be asked regarding the debate surrounding the relevance of science to young people’s everyday lives. Perhaps teachers have neglected young people’s perspectives because we, as science educators, adhere to our own expectations of students, or maybe it is because we were all children once, so we think we know how young people think and view life. Teacher’s expectations are significant to all educational institutions (Bybee et al., 2014). We may not ask ourselves questions about how the new generation is thinking about science. Stakeholders invest in developing the science curriculum mainly with a view to raise the numbers of potential employees in the future. For example, schools and universities hold career fair days, which are a great opportunity to inspire and inform young people about different jobs and potential career paths. The goal of career fairs is to bring professionals to schools to talk about their jobs and their contributions to society. Experts and speakers come from many different fields, such as the military, local businesses, healthcare, railway companies, banks, etc. Many of these employers and other professionals focus on science as a critical subject within schools. Despite these efforts, the gap in STEM jobs remains unfilled. To study the problem, we tried to briefly track the history of the term ‘relevance’ in relation to science education, which will be discussed in the following pages.

2.3. The history of reforming science to make it relevant

There is a long history of reforming science education in the pursuit of relevance. In this section, I will briefly discuss science curriculum reform from the late 1950s to the present. Presenting this timeline will illustrate how stakeholders and researchers have historically thought about the relevance of science. We will see the progress of viewpoints about how to make science relevant and ideas drove influencers in this area during each time period. Researchers call the period between the late 1950s and the early 1960s the ‘golden age’ of curriculum reform (Bybee, 1997). This time is also called the ‘Sputnik era’ for the huge shock the US faced due to Russia’s rapid advancement in technology and specifically space exploration (Wissehr et al., 2011). This sparked a massive science education reform movement in the US, which then followed in many other countries, including the UK, Germany and Israel.
(Stuckey et al., 2013). Many science curriculum projects were developed and implemented across all age groups.

The primary goal of this curriculum movement was to improve students’ attainment levels in science (DeBoer, 2000). It was motivated by a vision of inspiring more students to enrol in science-related fields of study, including medicine and engineering. At that time, scientists’ views about science education were reflected in the curricula that were developed. The main focal point of these curricula was making science education more effective in terms of relaying scientific facts, theories and concepts. Some researchers (Jones and Young, 1995, Osborne and Dillon, 2008) argue that the guidelines and goals for science curricula that the AAAS published in 1962 seem to target a specific group of students; that is, the group they assume will achieve their vision of inspiring more young people becoming scientists, medical doctors and engineers. The guidance and approach that was developed in the US in the 1960s influenced many other Western countries. Based on this approach, in practical terms, that target population is small. However, this causes a gap and creates a problem that has lasted until today in the European Union and other Western countries (Stuckey et al., 2013), as currently, a relatively small percentage of the current generation of young people want to pursue science in the future. Adopting an approach that targets a specific group of young people was encouraged by many researchers in the late 1960 and 1970s. Such an approach would leave only a small group pursuing science for the future, whereas the main aim of the whole science reform movement was to attract more students, not fewer (Osborne et al., 2003). Pella (1967) argued that the ‘golden age’ also failed to incorporate technology as well.

The failure of this movement led to a new and very significant idea in the area of science reform agenda: ‘scientific literacy for all’. This idea became a significant factor in the argument for revolutionizing science education in general and science curricula in particular (Pella, 1967, Hurd, 1970, Hofstein and Yager, 1982, Fensham, 2008). This movement can be considered the second science reform movement. This second movement highlighted the importance of making science accessible and available for everyone, not only for those who might want to do science in the future (Stuckey et al., 2013). The core aim of this movement was to help all students learn science for their personal lives and for living in society. This could be accomplished by helping young people understand the role of science in their lives. To achieve this goal, science needed to be taught in a broader way than before and also needed to relate to personal and social goals (Hurd, 1970). Adopting this approach of context-based learning means that science lessons should be practical for everyday life, from the personal to the social.
According to some, helping young people to recognize the role of science in everyday life will make science more relevant to young people (Gilbert, 2006). This claim sounds great but, unfortunately, as Fensham (1976) wrote, in fact creates a more significant gap and leads to an inadequate consideration of social participation and the implications for and outcomes of science within the development of the curricula. This problem also exists in some context-based learning curricula, where the context of science teaching is still disengaged from social, environmental and financial implications (Gilbert, 2006).

In the 1980s, many researchers acknowledged the ‘years of crisis in science education’ that existed in the 1970s (Hofstein and Yager, 1982). The results of the aforementioned gap had begun to show. The number of young people enrolled in optional science courses were on the decline. These unpleasant statistics left stakeholders and policymakers with a great deal of dissatisfaction with the long road towards developing science programs that had begun in the 1950s. It was a crisis; young people were not interested in pursuing science, despite all of the time and effort that had been invested. This crisis was a wake-up call for rethinking the aim of teaching and learning science. The National Commission on Excellence in Education, therefore, published a paper in 1983 entitled ‘Features of Quality Curriculum for School Science’ which described the goals of teaching science (Yager and Hofstein, 1986, Harmes and Yager, 1981). You can find the list of these goals in a paper by Yager and Hofstein (1986).

To summarise, the goals aimed to promote science as a career path and show the value of science to society (Yager and Hofstein, 1986). The social perspective is a new dimension that researchers have recently started to explore and promote. Based on this perspective, the new curricula are not only aimed at those pursuing a career path in science. According to these ideas, a good science curriculum should prepare young people and give them enough knowledge to be useful, helpful citizens.

From the 1990s to the present, the science curriculum reform movement has continued with a focus on growth and accomplishment (DeBoer, 2019). Large schemes have been launched to reform and reshape science education curricula. In the UK, Germany and the Netherlands, for example, high school teachers have been engaged in the process of designing new science education curricula (Stuckey et al., 2013). Since the 1990s, two primary approaches have been identified. The first approach emerged at the end of the 1990s and the beginning of 2000s in many Western countries and that approach involves making science more meaningful to students’ lives by implementing context-based science education (King and Ritchie, 2012). The second approach is a socially oriented method of science education. This approach aims to present sociocentric issues in the classroom in order to teach young people about the current
and future implications of science and technology for society (Marks and Eilks, 2009, Sadler, 2011), which, as a result, will increase the relevance of science education. Both curriculum approaches have shared the goal of education through social participation (Holbrook and Rannikmae, 2007, Roth and Lee, 2004). This has been presented as an alternative to how scientific facts and principles were taught in the 1950s and 1960s, methods that are still used in many countries in the world today (Hofstein et al., 2011).

Based on the historical perspective of the meaning of the term ‘relevance’ in science education, we can see how the use of the term has changed over time. Relevance in science education has many aspects. Stuckey et al. (2013) suggested that there are at least three dimensions of relevance in science education. First, there is the relevance of preparing young people for future careers in science and engineering. Second, there is the relevance of understanding scientific phenomena and dealing with the challenges in one’s personal life. Finally, there is the relevance of helping young people become responsible future citizens in society. In the next section, I will discuss the most vital project in the area of science education which is still ongoing: the study that tracks the development of young people's career and science-related aspirations.

Aspiration in science education: the ASPIRES project and science capital

For decades, one of the most-explored ideas in STEM literature has been how to engage young people in science, specifically, how we encourage young people to consider pursuing careers in science in the future. There is a long history of looking into young people’s interest in, attitudes about and motivations for studying science. These studies have doubtless made some difference, but the issue of young people not being interested in science and of feeling that ‘science is important but not for me’ continues (Jenkins and Nelson, 2005). There are worldwide concerns about young people abandoning science, technology, engineering and mathematics (STEM subjects) after the age of 16 (Wang and Degol, 2017). Studies show that women, working-class individuals and some minority groups are underrepresented in STEM, which makes the government and policymakers worried about the economic future. Such an absence of interest creates an employment gap in a science-related fields (Wang and Degol, 2017, Beede et al., 2011). In the next section I will briefly present two large science-related projects in the UK: ASPIRES and Science Capital. I will talk about the inspiration behind those projects and their outcomes. The reason I have chosen to discuss ASPIRES and Science Capital in this study is because this research was done in the UK and most of the current data about science education in the UK comes from these two projects.
ASPIRES

In the UK, a project called ASPIRES was created by a team of experts from Kings College London. The main aim of the ASPIRES project was to explore and investigate what inspires young people between the ages of 10 and 14 to want to pursue science in the future. The project lasted for five years. It was funded by the UK’s Economic and Social Research Council (ESRC) as part of its Targeted Initiative on Science and Mathematics Education (TISME) 2. The team behind ASPIRES used a combination of both qualitative and quantitative methods. They conducted a survey and an interview with some students and their parents. The data was collected in three stages. The first stage focused on students in their final year of primary school, while the second stage focused on students in their second year of secondary school and the last stage focused on students in their last year of secondary school. Overall, around 19,000 students completed the survey. About 9,319 surveys were completed by Year 6 students, 5,634 by Year 8 students and 4,600 by Year 10 students. The number of subsample participants who were chosen to do interviews with their parents was 83 students and 65 parents across all the groups.

The findings of the ASPIRES project are as follows:

1- Most of the young people involved had high aspirations of bright futures and interesting jobs but not necessarily in science-related fields.
The study shows that most families are supportive and appreciate education, even if the parents are not educated themselves, which goes against the idea of a ‘poverty of aspiration’. However, aspirations to become a scientist were still low across the 10 to 14 age group, at only 15 percent.

2- Liking science is not enough to encourage young people to pursue science in the future, nor is disliking it. Liking or not liking science lessons, therefore, is not the problem.

3- Knowing someone who works in a science-related career plays an important role in young people aspiring to work in science. This is called ‘science capital’.

4- Lack of knowledge is one of the major obstacles facing young people and their families.

5- The cultural stereotype that ‘scientists are brainy’ makes young people less confident about pursuing science and may question themselves and stay away from science-related aspirations.
6- Boys seems to hold more science-related aspirations than girls, which is evidence of gender differences. The study shows that girls are less likely to want to pursue science in the future than boys.

None of the findings explore how young people connect science to their own lives. By ‘connect’, I am referring to how students see the relationship between science and their everyday lives. There is no data related to how students see science in relation to their everyday lives or whether they see it as merely a subject at school. The gap between boys and girls is worth investigating. There is no clear answer as to why girls are, at such a young age, less inspired to pursue science or whether it is related to cultural influence or a lack of knowledge. However, a clear answer exists, even if researchers have not clearly identified it. Existing literature shows that some of young people think science is for brainy people or white men (Archer et al., 2013). After spending much time reading research about this topic, I would say that I agree with the researchers who state that increasing girls’ interest in science is not the solution (Baker et al., 2014). Interest is different from aspiration.

2.4. Science Capital

Science capital is an idea that can help us understand why some people pursue science and others do not, which is achieved by studying people’s science-related experiences and participation. Science capital is a theoretical tool developed by the research teams at University College London, King’s College London and the Enterprising Science project in the UK. The research was inspired by the French sociologist, Pierre Bourdieu, who first introduced the idea of cultural capital. He claims that the social classification and cultural experience of a person impacts his or her future path.

The simplest way to explain this concept is by imagining that each person is holding a science bag or ‘hold-all’. This bag contains all of the experiences and involvement that person has had in relation to science. Science capital is about defining those experiences and being able to answer four questions:

- What do you know about science?
- How you see yourself in relation to science?
- Who do you know in science-related jobs?
- What activities do you do that are related to science and which might shape your feelings and attitudes about science? (Archer et al., 2012).
For example, what activities are young people doing after school; do they go to museums or participate in science clubs? Or are they trying science-related experiments at home using instructions from science magazines or YouTube videos? All of these experiences shape people’s views and perspectives towards science and influence whether they will pursue STEM careers in the future or not. Researchers claim that the more experience with science people have in their lives, the more they will see science as essential and this can increase their chances of pursuing science in the future (Banerjee and Santa Maria, 2012). The more positive experiences related to science people have, the more science capital they have. Science capital is not constant and can be changed over a lifetime (Archer et al., 2015).

Results from a survey of 3,658 students from 11 to 15 years old show that, in the UK, about five percent of young people have a high level of science capital, while about 68 percent have medium science capital. Twenty-seven percent of young people in the UK have low science capital (Archer et al., 2012). The study offers eight important insights into the dimensions of science capital. By knowing and recognising these dimensions it is claimed we will be able to improve the relationship between people and science. Understanding these dimensions also presents a great opportunity to increase young people’s involvement in science, according to researchers. The eight dimensions cover young people’s experiences, knowledge, behaviour and attitudes related to science. They also cover how much science capital they have, which influences their relationship with science. In June 2016, the Transforming Practice blog by the Science Museum Group in the UK introduced the concept of ‘science capital’ and explained how science capital can be helpful to developing science classes in schools. They applied the idea of science capital to the context of a science museum and provided examples. The diagram below is from the Science Museum Group blog. I am a visual person; I found that the diagram explained the ideas in a simple way and was comparable to the diagram I use later in the chapter on theoretical views. Both diagrams explore the influences that impact the relationship between individuals and science from different angles.
2.4.1 Science literacy
According to many science educators, science literacy is one of the primary aims of science education. The term ‘science literacy’ has been used for more than four decades (Science, 1990, Science, 1994, Millar, 1998, National Academies of Sciences and Medicine, 2016, Laugksch, 2000, Sadler, 2004, Wenning, 2006, Holbrook and Rannikmae, 2009, Association, 2010, Gregario, 2010). Science literacy was first used by Hurd in 1958 (Laugksch, 2000) and refers to science education and the public’s understanding of science. While researchers use the term in many different contexts, the most accepted explanation is that science literacy is about science education. There is, however, no agreed-upon definition of science literacy available in the literature; the term is still vague and has many meanings and definitions (Gregario, 2010).

The most commonly used definition of science literacy is that it is the knowledge and skills with which individuals engage with science in terms of both personal and public issues (National Academies of Sciences and Medicine, 2016). When we talk about science literacy, we must mention the Programme for International Students’ Assessment (PISA), which measures literacy in reading, mathematics and science. In fact, the ASPIRES project adopted their definition of science literacy from this programme. The programme was set up in 1997 by the Organisation for Economic Co-operation and Development (OECD). The aim of the
program is to provide appropriate data to governments on ‘policy oriented and internationally comparable indicators of student achievement on a regular basis and in timely manner’ (Harlen, 2001). Since 2000, the programme has been used in over 80 countries around the world. The PISA offers a different perspective compared to other assessment practices in the science education community. Whereas most current assessments focus on attainment level and what knowledge and skills the student has achieved over the past year, the PISA aims to predict how the students will apply their scientific knowledge and skills in future (Bybee and McCrae, 2011). PISA has been designed for young people to complete after finishing their compulsory education at age 15. The science subjects that are covered by the PISA include Chemistry, Biology, Physics and Geosciences. The creators of the PISA have also adopted their own definition of science literacy; according to the PISA report, science literacy is the measurement of someone’s ability and confidence in relation to science, which is determined by examining the learner’s ability to apply what they studied at school in real life situations. It is also based on how well individuals understand science keywords and terminology and are able to deal with scientific challenges in everyday life. As well, science literacy is related to the ability of young people to describe scientific occurrences and conduct scientific experiments and present research with evidence (OECD Programme for International Student Assessment (PISA), 2015, July 12). From my perspective, however, the last element – the ability to carry out scientific experiments – is not a widely applicable aspect of scientific literacy, as not many young people require such an ability in everyday life.

If science literacy is the knowledge and skills individual possess and use in their everyday lives, an important dimension relating to the everyday experiences of young people has been omitted. We can test and measure the level of knowledge that young people have, but we do not know if they really see how this knowledge is connected to their everyday lives. In reality, there are people who never studied science but who know how to drive, who know how to fix their cars or who can change any part of an engine or another machine. At the same time, they might not know anything about why or how their job is related to science or anything that would make them value science. For example, my father, who is illiterate, thinks of fixing the water pump as a life skill that is not taught in school. He does not consider fixing the water pump to be science. He believes in the value of this life skill, but he would never see it as a science-related job. For me, as a science researcher, science literacy is about measuring and testing how young people apply their knowledge and skills in real life situations, not only in surveys or interviews. Science literacy is about practicing science mindfully and understanding that science not only
about passing an exam and getting a high grade. I also think science literacy is about at least knowing the basics and by ‘the basics’, I mean knowing the relationship and the connection between science and real world situations and being able to deal with related challenges and solve problems in the real world.

2.4.2 Science-related attitudes, values and dispositions

The second dimension is a combination of attitudes, values and dispositions which are defined differently from each other in the literature. I assume that researchers like Archer believe that these are related to each other when looked at as a thread of individual feelings, beliefs and behaviour. Attitudes towards science can encompass the feelings, beliefs and values held by individuals about science, including school science, technology, positive and negative developments in society and scientists themselves. Attitudes about science comprise a massive issue in science education and have been explored and discussed from various perspectives (Bybee and McCrae, 2011). There are two major categories of science-related attitudes in the literature. The first one is the attitude towards science, which means, e.g. interest in science, attitude towards scientists or attitudes towards social responsibility in science. The second one is a scientific attitude, i.e. open-mindedness, honesty or scepticism. Having a ‘scientific attitude’ means aspiring to know, understand and wonder and having the courage and desire to explore scientific statements, investigate the meaning of data, search for proof and consider the results of research (Gardner, 1975, Osborne et al., 2003, Bybee and McCrae, 2011).

Research studies indicate that there is a correlation between achievements in science courses and a positive attitude towards science. Specific factors within classroom environments, including personal encouragement, applying different teaching strategies, creative learning activities and student-centred instructional designs can foster positive attitudes which, as a result, will improve student attainment levels in science (Osborne et al., 2003, Russell and Hollander, 1975, Shrigley et al., 1988, French and Russell, 2006). Attitudes about science and scientists are not all that affects students’ attainment levels in science classes; they might also be impacted by students’ individual views on science, their awareness of potential future careers and their participation in science classes. Students who held positive views paid more attention to classroom instruction and participated more in science class activities (Germann, 1988, Jarvis and Pell, 2005).
In terms of dispositions, most of the literature describes dispositions as different from attitude and values (Van der Rijst et al., 2008). The views of Archer et al. (2015), however, are based on Bourdieu’s (1984) original quantitative study on cultural capital and the review of this work by the UK’s Bennett et al. (2009). Bennett et al. (2009) state that artistic aesthetic dispositions are a significant element of an arts-based cultural capital. It seems likely that the case is the same for disposition and science capital (Archer et al., 2015). Historically, the term ‘dispositions’ is not new; it has long been used in educational research, albeit inconsistently (Van der Rijst et al., 2008). Katz and Raths (1985) describe dispositions as ‘a pattern of acts that were intentional on the part of the teacher in a particular context and at particular times’ (p. 303). In Katz and Raths viewed dispositions as something that is strongly connected to individual behaviour (Katz and Raths, 1985, Van der Rijst et al., 2008). It becomes clear in philosophical arguments, however, that dispositions are not a summary or observation of someone’s behaviour but the concept of dispositions is important (Van der Rijst et al., 2008).

It is difficult to find existing studies about the value of science, but I assume the word refers to realizing the importance of science and understanding that it is not only a subject at school, but is, rather, something that is around us every day. To encourage young people to value science, we must show them how science is connected to their everyday lives, how it can change lives and how it is accessible to anyone. We must also teach young people to appreciate science and to notice and consider the role of science in everyday occurrences around them, especially in things they might take for granted, like transportation or overcoming a flu. If we look at the attitudes, values and dispositions surrounding science as one collective influence, the definition will be a combination of young people’s science-related feelings, beliefs and values.

2.4.3 Knowledge about the transferability of science (skills, knowledge)

This factor involves educating young people about the opportunities that are available to them in the industry. Raising awareness of the possibilities available for young people should be considered a practical application of symbolic scientific cultural capital (Archer et al., 2015). Archer et al. (2015) argue that the importance of knowledge about the transferability of science is supported by the results of the UP MAP project. The project’s results show that knowledge about transferability is one of the strongest influences on young people’s decisions about their future path and that students are more likely to take physics or math after the age of 16 if they think it would be valuable and helpful to their future careers (Mujtaba and Reiss, 2014). Understanding the value of qualifications in science is a practical application of cultural capital.
with consideration of unequal social standings resulting from inequality between schools and families (Brown et al., 2009). The missing piece of this puzzle is to understand how young people view science and to what extent they see it as being connected to the real world. We therefore need to help young people realise how science is related to many career paths and try to dispel the belief that science is a difficult path to pursue. Providing enough information and expanding young people’s visions and perspectives of their options in science might be achieved by first shedding light on students’ everyday interactions with science.

2.4.4 Consumption of science-related media

This factor is about exploring the amount of science people experience on a daily basis, such as through TV shows, games and books related to science (Archer et al., 2015). PISA data from Hong Kong reveal a relationship between the amount of science consumed on a daily basis and children’s views towards science (Ho, 2010). Ho (2010) found that everyday exposure to science increases children’s interest, self-efficacy and high attainment levels in school science classes (Ho, 2010). Examples of science consumption include museum visits, science fiction books, video games, water parks, etc. A famous example of how the media can foster an interest in science and positively impact people and promote science is Brian Cox. Cox is a professor of Physics at the University of Manchester; he is best known to the public as a science program presenter. The most famous program that he hosted was the Wonders of... series; it is widely considered the most-watched science program in the UK. Cox is also known as a writer of popular science books, for which the sales exceed 1.3 million copies; his books include Why Does E=mc²? and The Quantum Universe (School of Physics and Astronomy, 2019). Cox was chosen as the 11th most influential man in Britain by GC magazine. According to UCAS, the number of young people applying for a university physics course increased by 52% between 2008 and 2012, and there was an increase of 20% in the number of young people taking A-level physics. Over the years, Brian Cox has become a well-known public figure who has drawn attention to physics into popular culture (School of Physics and Astronomy, 2019). He is an example of how the media can help to promote science and attract young people to the STEM field in an exciting way.

2.4.5 Participation in out-of-school learning activities

The term ‘outdoor learning’ has been used for more than 20 years. Learning does not only occur in a classroom setting. Outdoor learning involves exploring either theories or practice in
outdoor environments, such as museums, zoos, parks, jungles and beaches (Waite, 2017, Huang et al., 2010, Eick, 2012). Frequent outdoor education can be crucial for children’s emotional, physical and intellectual development and can be achieved through ongoing experiences in nature (Kellert, 2012). By interacting with nature on a daily basis, children can improve their concentration and expand their overall cognitive abilities (Wells, 2000). Outdoor learning settings can also expand children’s perspectives on the entire world around them (Yıldırım and Akamca, 2017). A considerable amount of literature has been published about the importance of integrating outdoor learning into traditional learning in early childhood education. These studies show that outdoor learning improves children’s cognitive, social-emotional and physical creativity skills, as well as their awareness, observations, understanding of cause and effect relationships and imaginations. It is necessary to combine education with outdoor settings for children’s needs with regard to nature, animals and soil to be communicated freely (Bilton, 2010, Godbey, 2009, Maller et al., 2006, Melber and Abraham, 1999, Ouvry, 2003, Studer, 1998, Yıldırım and Akamca, 2017, White and Stoecklin, 1998). Teaching science outdoors can advance children’s scientific senses by teaching them how to observe their surroundings, measure things, make connections and see how everything works in a system (Hofstein and Rosenfeld, 1996, Fägerstam and Blom, 2013, Ayotte-Beaudet et al., 2017). Outdoor learning can provide proof for students of the connection between science and the real world. It can be used to improve students’ observational skills and spark wonder about what is inside of them and in the outside world. The free, liberated environment might also trigger hidden scientific interest within students.

2.4.6 Family science skills, knowledge and qualifications

Family is considered an important source of students’ motivations to work in STEM fields (Harackiewicz et al., 2012). According to many STEM students, their families had a significant influence on their career choices (Sjaastad, 2012). Studies have shown that families have a major impact on children’s interest in relation to science, but it still unclear how this happens and how much time is needed for children to benefit from this effect, as the topic has not yet been explored enough (Harackiewicz et al., 2012). Nevertheless, families who hold positive attitudes towards science have reflected on being an encouragement for their children to achieve high grades in science (Hidi and Harackiewicz, 2000). Palmquist and Crowley (2007) believe that having a family member who is interested in the same area can encourage students’ interest, as they can act as a support and provide learning resources. Moreover, family
engagement in scientific ways of thinking can help their children to develop a sense of critical thinking in general (Fender and Crowley, 2007).

Previous research suggests that by looking to family members’ education levels and occupations, we might be able to anticipate children's interest in science and their performance levels or career choices. As older family members likely spend a lot of time talking about their careers and the paths they followed, this might positively influence their children (Ho, 2010, Harackiewicz et al., 2012). Simpkins et al. (2006) discovered that educated parents have a positive influence on the number of science courses that young people take in high school. Moreover, educated parents may hold high expectations about the number of science courses that should be taken in school and the performance level that their children should achieve, which may have an impact young people’s decisions (Simpkins et al., 2006). We cannot be sure if this impact is positive or negative, as many students may take science classes just to please their parents or other family members. Parental expectation has been heavily studied and has left us researchers with the same question: what if students do not really see the relationship between their lives and science but, rather, see science as a subject at school that they can succeed in to impress their families? Germann (1994) argues that well-educated families have a tendency to promote a home environment that stresses the value of education and encourages young people to learn science. Although research has illuminated the association between parental education and childrens’ aspirations towards science, no study to date has examined that relationship and the studies that are available show contradictory outcomes (Dabney et al., 2013). According to some studies, uneducated parents have the opposite influence on their children; James and Pafford (1973) argue that children with parents who do not work in professional fields are less engaged with science and less likely to participate in science courses compared with children who have parents who do. I think that this an unfair assumption, as most parents, especially those who did not get the chance to go to school, realize that one’s quality of life can be better if they continue studying.

2.4.7 Knowing people in science-related roles and jobs

Archer et al (2015) suggest that knowing someone, like a teacher or family member, who works in science-related fields has a positive impact on young people’s choices related to science past the age of 16. Their results suggest that students with parents, other family members or neighbours who work in science-related jobs are more likely to aspire to pursue science in the future compared to students who do not have anyone around them working in science (Archer
et al., 2012). Mujtaba and Reiss (2014) call the teacher or family member a ‘key adult’, who, over time, can motivate, encourage, or inspire young people to choose careers in science in the future. But these ideas about influential people raise significant questions. For example, what about the case of children who know no one working in science, or who have just moved to the country? Furthermore, we might ask what Mujtaba and Reiss (2014) consider the relationship between the ‘key adult’ and the child has to be. If all that is required is to ‘know’ someone, then, for example, most children ‘know’ their GP or dentist. But would simply knowing someone in this way impact students’ understanding of science, and their belief that it is easy? Further research is needed here on what sort of relationship and what kind of role model actually affects young people’s attitudes to science. The research cited here claims that knowing someone in a science-related field can inspire students over time; if this is something that happens over time, then this element is similar to the previous element about family education status and professionalism. This point too requires further investigation.

There are serious questions here too about the need to know someone who works in a science-related job and is content with what he/she is doing; some people who work in science-related jobs do not like what they are doing, and this could be a negative influence. More research is needed to ascertain when it is sufficient simply to bring someone to a school to talk about their laboratory or railway job.

These questions reflect also on the role of the science teacher as a role model: what is the possible impact of science teachers on their students, given the workloads and academic targets they are so focused on? What would it take for teachers to be creative and inspire young people when they see 28 students with different ability levels for only 50 minutes? From this perspective, the students already know someone who works in a science-related job: their science teacher.

2.4.8 Talking to others about science in everyday life

Talking to parents, siblings and friends about science has an influence on young people’s views and understanding of science. Lyons (2006a) stated that speaking about science at home can improve students’ performances and their interest in school science classes. I searched for resources to help me understand this point further. I found an article refer to the type of talking to be similar to the scientists’ talking to the public in public events or talking about science in a TV program. There is no data about that kind of talk for an average person in everyday life. From my perspective, understanding science depends on how well-informed the other person
is and how much time she/he has spent in busy life to develop an interest in science. What kind of discussions and topics can be discussed with young people? What issues can be addressed in everyday life? How many times can science be discussed, and for how long, in general? Do online discussions count or do they count as media consumption?

This study aims to understand young people’s perspectives on science and how young people articulate their relationship to science. A large amount of literature has explored what motivates young people to study science or investigated what would increase young people’s interest in science. For example, (Eccles and Wang, 2016, Karpov and Razina, 2018, Arís and Orcos, 2019).

Earlier, I introduced two projects related to this issue that have been done in the UK and one of which is still ongoing. The results of these studies shed light on an essential aspect of understanding the relationship between young people and science. Throughout this research, I have been looking to discover where I can find students’ views and opinions about science. I searched the available literature in an attempt to find young people talking freely about what science means to them. My ultimate aim is to listen to young people talking openly about this subject, which was one of my main reasons for choosing to use the photo elicitation method. From the beginning, I was interested in seeing how young people would express their relationship to science through taking photographs and by speaking about those photos. I read the ASPIRES report many times and I think the main issue with it is that ASPIRES focuses on school science, whereas I think the missing piece of the puzzle is connecting school science with science outside of the classroom. By ‘outside of the classroom’, I do not mean after-school activities; I am referring to how those students see science as connected to their everyday lives and not to what they aspire to do in the future or which path young people really desire to follow. In my opinion, if you cannot see or feel the connection between yourself and the concept at hand, then no matter what external efforts are made, you will be not able to make this connection and you may therefore simply pretend that you do. One of the main purposes of this research is to help us as educators define this connection; no doubt any link we describe will not apply to all young people and that is why I used the cultural model as a lens through which to view my research. It will help me to understand the shared models around science within specific groups in specific circumstances. The results show a lot of shared views and understandings of science. I think what is missing is hearing from young people directly about what science for them is and how they see science as connected to their everyday lives.
next section, I will present some studies that discuss the importance and the impact of students’ voices on the topic of educational practices in general.

2.5. The importance and practice of student voices

We do not consciously pay much attention to young people’s voices on a typical day. This is not something we do on purpose. We used to think that, if students were showing up every day at school, attending their classes and doing well in exams, they were fine and, therefore, everything was under control. We believed that we could make students take actions and make decisions by letting them either plan a dance class or develop a science project and that students’ engagement with typical school activities is proof that their voices were heard. We made these activities seem compulsory by insisting that everyone become involved at least with one activity. All of that happened based on ethical intuition and on what we assumed we knew of we assumed we know what is useful and beneficial for young people. This research is not about student's voices; however, the issue I am discussing in this study is somewhat related to that topic. This study is about exploring how young people see their relationship to science through the use of visual methods and interviews. The dominant ways that young people describe their views, opinions, feelings and questions about science lead to investigate on the literature about student's voice. The importance placed on young people’s voices is growing and awareness of the impact and benefits of including students’ voices is also on the rise. Many organisations have started to include young people and introduce them as partners in the process of change. For example, many groups have involved disabled children and other young people in their research in the UK (BAILEy et al., 2015). Children and young people have also been included in health and well-being initiatives in the UK (Butcher, 2010), municipal councils in Israel (Nir and Perry-Hazan, 2016) and community art hubs in Canada (Hauseman, 2016).

Teachers who have no interest in students’ voices are not necessarily guilty of ignoring students, of course. Teachers are typically part of the culture in which the ideas that we know better as adults and that educators know more than young people are widely accepted. Research on adults who have left school shows that they often described their school experience as an impersonal one, where they had no voice and where no one cared about their opinions (Pope, 2008, Cook-Sather, 2014, Earls, 2003). This claim sheds light on the importance of listening to students in order to improve the school experience for everyone. Moreover, the research also shows that student isolation is often a result of students feeling disengaged at high school. Such
feelings of isolation and disengagement contribute to low attendance rates, students’ low self-esteem and low attainment levels; as a result students may drop out of school (Fullan, 2015, Lukes, 2015). The term ‘student voices’ can be looked at from two angles. It can mean a superficial action that elicits the basic opinions of young people regarding school problems and their suggested solutions. It can also refer to the in-depth voices of students that are elicited from a partnership between young people and adults formed to solve school-related problems. Student voices can be utilised as guidance for those seeking changes and improvements (Cook-Sather, 2002, Mitra, 2003). The value of students’ voices in the context of a partnership such as those described in these studies is undeniable; many researchers have agreed that listening to students’ voices improves classroom practices (Robinson, 2014, Niemi et al., 2015, Mitra and Serriere, 2012, Kincheloe, 2007). These researchers may not use the term ‘student voices’; they also use the term ‘consultation’. A consultation is a form of teachers conferring with students to improve the teaching and learning process in the classroom, by eliciting feedback on instructional techniques, curriculum content, evaluation and assessment opportunities and other concerns in the classroom (Rudduck and McIntyre, 2007, Rudduck, 2007). In some countries, engaging pupils in informal and formal practices of studying their own educational procedures and teaching experiences has expanded as a result of endeavours to fulfil the requirements of an international decision approved in 1989 via the United Nations Convention on the Rights of the Child. Although England had been exemplary in terms of supporting and practising a student voices-centred approach (Alexander, 2013, OFSTED, 2000), the existing governmental stresses have shifted away from centring on students’ voices. In the UK, more commonly, a variety of authority projects have appeared to control the consultation of children concerning strategies that influence them directly (Elwood, 2013). Research shows that students develop academically when their teachers structure their lessons based on the value of the students’ voices, especially when young people are given the ability to work with their teachers to enhance the curriculum and teaching techniques (Oldfather, 1995, Rudduck and Flutter, 2000). When teachers’ pay attention to their students’ experiences and preferred learning styles, student interest in coursework and learning increases as a result (Daniels et al., 2001). Consultation helps students achieve a sharper sense of their skills and teaches students about the differences between studying techniques, multiple intelligences and emotional intelligence (Mitra, 2004, Lee and Zimmerman, 1999, Johnston and Nicholls, 1995). It also offers a better understanding of students’ own learning processes, for both their teachers and the students themselves (Rudduck, 2007).
This is because, first of all, young people are often keen to raise their concerns about topics that adults might not notice or otherwise prevent them from speaking about. In the current educational system, students who are failing subjects and do not obtain their school requirements or are at risk of leaving the school are often willing to offer insightful advice on the challenges with the existing school structure and culture (Smyth, 2007). Struggling students tend to refer to systems and classroom techniques that obstruct learning, lead to a lack of opportunities to develop thoughtful relationships with adults and promote overt discrimination (Collatos and Morrell, 2003, Nieto, 2013). Secondly, there is some indication in the related research that the attainment levels of young people have a direct relation to the likelihood their voices will be heard; some research links a student’s grade point average (GPA) with their level of involvement or activism (Conner and Slattery, 2014). The direction of this relationship is not yet clear. Thirdly, student voices play a significant role during changes and the implementation of new processes. Student voices can enhance the quality of these reforms and implementations. Young people can be a source of valuable information on the reform process; young people’s perspectives provide otherwise unavailable information on the subject of their own experiences as they relate to educational changes (Kushman, 1997; Mitra, 2018). Another example of the value of eliciting students’ voices is that it also helps in reshaping and improving the reform process. In New Zealand, researchers used student feedback to critique the curricula reform (Mitra, 2018). In Kenya, researchers tried to find ways to use student voice in their critiques and to implement sex education (Cobbett et al., 2013). Additionally, student voices can also help parents to understand the school experiences of young people. Levin (2000) suggests that student voices can act as a bridge between teachers, schools and families.

Furthermore, student voices also have an impact on school culture. Data has shown that when young people are asked about their opinions, they usually express a strong desire for a positive, healthy relationship with their teachers (Lodge and Lynch, 2004, Yonezawa and Jones, 2007), which is the opposite of the lack of respect and isolation often reported in young people. Student voices, however, can have a strong influence on their relationship with teachers and on the culture of the school as well. In fact, student voices can lead to an improvement not only in students’ relationships with their teachers, it also can improve the quality of the school experience overall (Fielding, 2001). Examples include moves to extend the period of advisory time or to pay more attention to the skills needed to understand new curricula. Finally, student voices do not only serve to improve the relationship between young people and their teachers or to build a bridge between schools and families. We can use student voices to enrich the
experiences of teachers and teachers-to-be in training and developing courses. Cook-Sather (2014) examined ways to enhance these experiences by using the student voices. He found that student voices can be used to encourage educators to rethink who has power over educational practices aside from the policymakers and other educational players. Cook-Sather (2014) claimed that by providing student voices to teachers and teachers-to-be, we can reduce or maybe even eliminate stereotypes educators have about their students.

Clearly, student voices offer many potential benefits to the education process and the quality of schooling. The way that student voices are addressed, however, is very important. In a climate in which schools are concerned about their image and comparative success, for example, student voices might easily be over-managed. Fielding (2004) has claimed that the current problem with how student voices are treated is that schools tend to look at their voices from the angle of control instead of seeking to learn from them. By contrast, one of the interesting practical implementations of listening to young people can be found in an experiment by Cook-Sather (2002) in the US. In that study, students took their teachers to their neighbourhoods and showed them where they lived and introduced them to their friends on the street. This experiment showed a significant improvement in the relationship between the students and their teacher. They felt more connected, which led to greater understanding and a more insightful relationship. This experiment shows the benefits of teachers understanding the backgrounds of the young people, their cultures and the direct influences on their lives. In general, the research has suggested that we need to carefully consider and plan how to involve students voices (Mitra, 2018). There is a growing body of research that explores the ethics of including student voices in research, activism and organisational changes. Research has also raised concerns about the criteria for including student voices. Many researchers suggest a diverse sampling based on gender (Groundwater-Smith, 2011), ethnicity (Cook-Sather, 2014) and ability (Flynn, 2014, Pazey and DeMatthews, 2019).

This literature review has shed light on the importance of using student voices in general, which is an area where young people have been listened to even less. The benefits of involving young people in decision-making are undeniable, though, especially in today’s climate of increasing communication, in which people can share their opinions about anything online; for example, on social media. We must ask questions and let young people speak in order to get the answers we need. Young people need to feel connected to the subjects they study and to their teachers as well. Student voices can and should be utilised as a power. Many of the studies mentioned above show that young people feel that they are not connected to and are neglected and isolated
from their school communities. We must do more research specifically related to science to understand the reasons that young people lose connection with science. This powerful tool – student voices – must be used to improve science and the educational system in general.
CHAPTER 3

Theoretical Framework

This chapter aims to demonstrate the theoretical framework utilised for this study. I will begin by exploring the meaning of ‘culture’ in general and specifically in a science context. I will then explain the meaning of ‘subculture’. From there, we will explore science as a subculture and also school science as subcultural. This comprehensive exploration will lead us to present the first theory in this study: cultural models. From the cultural model, I will move on to introducing the border crossing theory. The border crossing theory will be used to look at the border that young people have to cross in order to overcome their struggles and challenges in relation to science education.

3.1. Culture

The lenses through which I will look at the topics in this study are the cultural model and border crossing theory. Both of theories study and explore culture and both try to understand the cultures of different groups and different settings. The umbrella topic here is culture. I started by examining the word ‘culture’ in the literature and in other studies. When defining any word, I always turn first to the Oxford English Dictionary, where the word culture is defined as a ‘way of life’ and also as ‘the customs and beliefs, art, way of life and social organisation of a particular country or group’. Culture, therefore, appears to be a powerful starting point for exploring the relationship between science and the real world. As per the definitions above, culture is one’s way of life, and, I would like to add, it’s also one’s way of thinking, according to the Oxford English Dictionary. Many researchers have tried to define culture, sometimes in a simpler way than others. For example, Ogawa (1986) defines culture as a human view of nature and our way of thinking and responding – a relatively simple definition. However, researchers have produced a variety of interpretations of culture, precisely because it is hard to define. In the context of science education: researchers have identified attributes associated with culture and established a list of cultural attributes. For example:

communication (psycho and sociolinguistic), social structures (authority, participant interactions, etc.), customs, attitudes, values, beliefs, worldview, skills (psycho-motor and cognitive), behaviour and technologies (artefacts and know-how) (Aikenhead, 1996, p7).
This long list of attributes can be seen as a way of understanding what culture is: as a hugely complex and varied set of interlocking, connected and yet quite different elements of human life. Other researchers have also defined culture by a shorter list of attributes. For example, Maddock (1981) list of the attributes of culture includes leadership, technology, languages, beliefs, attitude, behaviour and authority construction. In school, for example, culture, for students, has been defined by two different views: Spindler’s *cultural phenomenon* Spindler (1987) and Wolcott’s *culture acquisition* (Wolcott, 1991). Cultural phenomenon is the way that students understand and experience the world, whereas culture acquisition is the experiences that come from learning at school (Wolcott, 1991).

Geertz (1973), on the other hand, sees culture as a combination of the structure of meaning and the symbols that are present in social interactions. It is, generally, a system of the symbols and patterns humans use for social communication purposes. Geertz defined culture from an anthropological perspective. Phelan et al. (1991) defined culture as the norms, values, beliefs, expectations and conventional actions of a group. This makes Phelan et al. (1991) definition of culture more specific than the anthropological view. The definition of culture that Aikenhead (1996) adopted for the border crossing theory was Phelan’s, which is still more limited than some of the others presented above. Phelan views culture as the norms, beliefs, anticipations, assumptions and traditional behaviour of a group. What makes Phelan’s definition useful for the border crossing theory is that it contains a small list of attributes which includes both educational attributes and anthropological attributes. Aikenhead’s research is also based on the work of Costa (1995), which is framed by Phelan et al.’s definition of culture. I will discuss Aikenhead on page 43. Having explored the various definitions of culture, I will now discuss the meaning of ‘subculture’.

### 3.2. Subculture

In addition to cultures, there are also subcultures. Subcultures are often classified by race, gender, beliefs, religion, ethnicity, social class, professional role, etc. Hence, everyone belongs to several subcultures at the same time. However, subcultures can cut across cultures, as a result of interactions between people in society; for example, an Asian Muslim female physicist and a European black male journalist. Socio-cultural interactions between people create a large number and combination of subcultures. Subcultures involve sharing culture; they are comprised of people who share (less or more) a set of norms, values, beliefs, expectations and conventional actions. Subgroups or subcultures have an influence on any context. In science
education, there are several subcultures that have a powerful influence on science learners’ understanding of science. Each subculture is usually defined as a group of people who share the same set of norms and values. In other words, each group shares the features of a culture that defines them as a subculture. For example, in science education, Furnham (1992) identified seven subgroups that have a powerful impact on students’ understanding of science: family, the school, the media, peers, society and the financial and physical environments. For example, the dominant religion of a culture may affect the physical environment in many ways, introducing segregation between men and women; this becomes part of the subcultures in which people live.

Science can be considered a shared social concept, one that is shared, for example, within a science class or peer group (Solomon, 1987). As a result, subcultures offer a way of understanding the problems that young people experience in science education. However, life-world, knowing and knowledge, which are created in everyday life, are often in contradiction with science-world knowing (Solomon, 1983), which can be an obvious reason for young people’s resistance to alter their perceptions of rational information with a scientific fact. Misconceptions about information are often rooted in one’s cultural experience, as young people have grown accustomed to hearing it as a fact from trusted individuals, like family members and friends. There is evidence that many students are not interested in altering their understandings based on teachers’ or textbooks’ abstract explanations (Hills, 1989, Cobern, 1996). It seems that we look to every aspect of life separately and deal with each unconsciously; for example, the subcultures of science, school, school science, the classroom, the family, etc. Young people move from one subculture to another unconsciously. These multiple cultures show how important it is to make the transition process between cultures smooth and natural. To do so, we need to be aware of these movements and to be able to recognise the barriers, because students are not stupid; they are just not educated (Aikenhead, 1996). I will discuss these transitions on section 3.6 Border Crossing. Next, I will briefly discuss science as subculture and school science as a subculture.

3.3. Science as a subculture

Science is considered a subculture; to be more specific, many researchers view science as a subculture of Western culture (Baker and Taylor, 1995, Cobern, 1996, Ogawa, 1986, Maddock, 1981, Pomeroy, 1994). As previously mentioned, a subculture is a smaller shared culture belonging to a bigger culture. In this way, science is often considered a subculture of Western culture, because scientists share a transparent system of language and symbols globally. They
have been sharing this scientific communication system since the seventeenth century. At that time, science was exclusive or limited to one social class; specifically, the language of science was seen as a white, middle-class language (Mendelsohn, 1976, Simonelli, 1994, Rose, 1994). Some authors used the term ‘WMS’ which has two meanings: either ‘Western Modern Science’ or ‘White Male Science’ (Elshakry, 2010, Aschbacher et al., 2010). Because this study was conducted in a mixed-background setting, almost 95% of the study participants are Muslim. Ten of the 16 participants wear a hijab. For this group, Islamic science can be seen as a subculture. Even today, Islamic science is mentioned and emphasised in science curriculums at schools and also at any scientific events in Arab countries or Muslim communities around the world. Anyone who studies science in the Arab region and then moves to Western countries will notice that there are hardly any references to the contributions of Islamic science in any books or at any events. Even the people who are not from Arab countries and do not speak Arabic but who are part of Islamic communities and organisations in any country will mention the great history and contributions of Islamic science as a form of encouragement for members of their community, especially the young people. Scientific communities within Islamic communities ultimately attribute everything to God, and there are many contradictions between Western science and Islamic science, which, in my opinion, has an impact on young people who study or live on both sides. It is beneficial to recognise Islamic science as a subculture, which will help young people and their science teachers achieve progress in science. Knowing young people’s backgrounds in terms of the way they interpret the world will help to connect the dots between what they already know and what is new information.

Placing science within a specific classification has made some authors view science as a cultural enterprise, which, as a result, goes against the philosophical presuppositions called ‘the universality of science’. This philosophical claim that science is everywhere is about sharing its ideas and solving problems. Science is not limited to culture, race, gender or location. The universality of science has, however, been the subject of intense debate within the science education community. The peak of this debate was at the 1993 and 1995 annual meetings of the National Association for Research in Science Teaching, when Munro (1993, p.3) asked ‘what does this tell us about those who believed such a notion?’. He received a variety of published responses that emerged from science educators’ cross-cultural perspective. An example of the answers received include ‘naïve’ (Ogawa, 1986), ‘suffering from "Cartesian anxiety"’ (Stanley and Brickhouse, 1995), ‘colonialist’ (Brickhouse and Stanley, 1995) and ‘racist’ (Gill and Levidow, 1987). The debate over the exclusiveness of science will undoubtedly continue. This perspective of science education views science as a cultural
enterprise, which, as a result, creates a revolutionary movement in the way of thinking about science amongst science educators.

3.4. School science as a subculture

School science is a powerful subculture in every society and has a massive impact on students’ daily choices. As explored earlier, many students view the science curriculum and science at school as content that has little or no relation to their everyday lives. School science is taught using curricula that often support stereotypical images of science, such as the fact that science is ‘socially sterile, authoritarian, non-humanistic, positivistic, and absolute truth’ (Tobin, 1998). The presence of these stereotypes in science class removes science from its culture; it is ‘presented a culturally and as a “truth”’ (Aikenhead, 1996). A stereotype is simply a common idea shared by a group of people about a particular thing. In general, the moment we hear the word ‘stereotype’, we usually immediately assume it is something negative. Although stereotypes can be positive or negative, I would say they are more often negative when it comes to science. The stereotypical image of science contributes to the negative effects on students; in regard to science as a career aspiration, for example. In school, students are surrounded by peers and friends who may have negative opinions about science as a future career. They might think it is hard or expensive or tell a story about a relative who failed and then quit pursuing science. This might not affect some students, as these negative stereotypes will mainly affect students who are less passionate about science. There are next to no studies on how peers’ opinions influence young people’s future paths in relation to science. Until now, despite efforts to strengthen the bond between school science and everyday life, school science is rarely practical for everyday life. Despite implementing more activities and tasks that were aimed at connecting school science to the real world, as Medvitz (1985, p. 15) claims, ‘Science learned in school is learned as science in school, not as science on the farm or in the health clinic or garage’. This shows how school science has an undeniable impact on students’ relationships with science. Science educators and communities may, however, try to present different views about the subculture of school science. They seem to still disagree with the idea that school science always conveys images of science as a subculture.

Various research has been done on school science culture in regard to both Western and non-Western settings. However, most culture-related research on school science was established in a non-Western context (Baker and Taylor, 1995). The data show a massive contrast between the subculture of school science and students’ own traditional cultures. Disparities abound
between the subculture of school science and people’s traditional cultures; this can influence their relationship towards science positively or negatively. One of the apparent obstacles in non-Western cultures is that they do not have a sharing system of meaning and symbols in science education, which, as a result, limits the process of cultural transmission and creates ethical problems in non-Western cultures. One of the goals of science education, however, is to make the process of transition from one culture to another smooth, which could result in forcing students to share and which, therefore, generates more obstacles. Attempting to force students to embrace another system and abandon their traditional ways of thinking about and viewing science is a form of ‘cultural imperialism’. Cultural imperialism, also known as the arrogance of ethnocentricity, is a term that describes forcing other people to abandon their traditional ways of thinking and replace them with scientific ways of thinking. From this perspective, school science acts to ‘enculture’ or assimilate students into the school science subculture. Forcing people to abandon their traditional ways of thinking can, however, weaken and discourage the group or leave individuals from that group disoriented.

School science as a subculture has a social purpose, with which science educators are familiar. Basically, they consider the social purpose to be one of their educational goals. These goals can be found within a group of people who are competing for privilege and power over the science curriculum. Fensham (1992) categorised social purposes in school science. First, there is societal self-interest, which is viewed as political. For example, in school science classes, especially physics classes, students who are from underrepresented backgrounds get ignored, while privileged students get more attention and support, and such students will do well on science exams and enter science-related careers (Rifkin, 2016). The other categories are an economic interest in business, manufacturing and labour. As well, there is the social purpose of self-interest in terms of maintaining a skilled workforce, like university scientists, as well as the societal group interests of empowerment. Lastly, there are the groups of students who have an interest in individual development and self-fulfilment. The school science subculture plays an important role in students’ relationship to science. Young people spend almost 30 hours per week at school. The school and school science subcultures affect young people’s perspectives toward science, as does the broader culture that young people are a part of and are thus surrounded by outside of school. The ways that groups within society think, perceive and model aspects of the world are called cultural models.
3.5. Cultural Models

To understand and operate in the social world, we use cultural models, similar in concept to mental maps shaped by culture. Cultural models are made up of the cultural mixing of ideas and practices that are expressed, authorised, approved and established in everyday life (Gee and Gee, 2007). These ideas and traditions offer us data about how to be a person, which behaviour is good and which is bad, what matters and what does not. A lot of social rules are found by investigating the perspectives of individuals or towards aspects of their lives, which we call cultural models. Cultural models influence and inform perception, awareness, emotion and enthusiasm, which, as a result, gives form and direction to individuals’ experiences. These models are deeply rooted in everyday practice, which leads us to assume that other people share the same ideas and practices as well. An example given by Gollwitzer and Sheeran (2006) is that, in the academy, while we might have the same academic goals and intentions in mind (e.g., being a successful student or faculty member), we might have contrasting ideas about how to approach this or about what forms of achievement will take us there.

In the context of education, it is very helpful to pay attention to cultural models. Cultural models play a significant part in everyone’s daily experience, including students, teachers, staff members and anyone else who belongs to any educational institution. One person may have an idea about how to be a good student which is supported by the culture, while, others may have ideas that are not. For example, making eye contact with a teacher is, in some cultures, a sign of disrespect, while in others, it is not. As a result of the conflict of understanding and lack of support from the environment, the individual will feel unwelcome and might come to believe that he or she is excluded because of some inherent characteristic. The social sciences and humanities have presented a different way of defining culture. In anthropology, culture is viewed as ‘a symbolic realm which arises within the frame of social structures’ (Preston, 1997, p. 38) and is ‘a way of life of a group of people, the sphere of complex practical activity, or praxis’ (p. 39). Through the lens of praxis, culture is seen as a set of ideas and concepts that are rooted in everyday routines and ordinary practices (Preston, 1997). This applies to the context of schooling; everyone holds ideas and opinions about schooling and the problem is that they do not all share the same ideas and views. This includes teachers, along with other school staff members, students, family members, community members and stakeholders.

Consequently, cultural models are ‘the unexpected, yet unspoken, mostly unconscious and taken-for-granted aspects of the world that contain shared implicit knowledge and involves the
process of identifying the complex element of beliefs and knowledge’ (Hamilton, 1996, p. 188). I found this definition to be the best explanation of the cultural models that I will explore in my data. Most groups in life have their own culture, although I am reluctant to say every group. In fact, everything we use or think about that has instructions came from someone’s previous experience. This applies to any context in life. For example, in the classroom, students do not come to class empty and with a completely fresh mind; they bring their assumptions, understandings, meanings and experiences of the world (Bada and Olusegun, 2015). Resnick and Schantz (2015) considers thinking, cognition and the assumptions that develop within a particular situation to be ‘tools of thought’. These tools of thought are created by the social assumptions, which are often tacit and taken for granted. Moreover, those tools of thought are designed and shaped naturally within social interaction, which showcases the relationship between individuals and their environment. From the cognitive anthropologist’s view, these assumptions and meaning forms are called ‘cultural models’ (Holland and Quinn, 1987, Shore, 1998, Sperber, 1985, d'Andrade et al., 1984, d'Andrade, 1995). Understanding how individuals personalise, organise and achieve cultural knowledge has guided the development of the cultural model theory (Herring, 1987). Researchers have a desire to understand how cultural knowledge is organised and coordinated within a cognitive framework. Researchers refer to cultural knowledge as schemata, which are held in our long-term memory and evoked in particular situations and environments (McCarthy, 1996).

The beauty of the cultural model is that it can be applied to any context. For instance, Fryberg and Markus (2007, p. 237) use the term ‘cultural models of education’ to refer to the sharing of ideas about education in society, like why we need to get an education, how to be a good student and what the ideal relationship between students and teachers is. These cultural models of education can be viewed as elements of the cultural context. The elements that define and structure the pattern of ideas and practices in the education field (Fryberg et al., 2013). These models are revealed and reinforced by individual interpretive frameworks or schemas, like ways of thinking, feeling and acting. These models are also combined and affected by public frameworks or schemas, such as practices, symbols, policies and social situations (Fryberg and Markus, 2007, Stephens et al., 2012). For example, in the context of higher education and European American culture, the best way to present yourself is by isolating yourself from others and from any social context. This view has been called an independent representation of self (Markus and Kitayama, 2010, Markus et al., 1997). In the contexts of other cultures, such as East Asian, Latino, Native American and African cultures, connecting with others is
essential, and you have to surround yourself with others in a social context. This perspective is called interdependent representation of the self.

In classrooms that consider and promote independent representations of self, developing students’ ways of thinking and their autonomy and self-confidence are essential aims of learning (Bellah et al., 1985, Bruner, 1996, Greenfield et al., 2006). Learning styles are guided and motivated by the value of individual, their uniqueness and their ability to make individual choices (Tobin et al., 1989). Good students in independent representations of self can be measured by the choices they make to ensure they achieve academic success and by their ability to stand out from others (Ross and Willson, 2012, Plaut and Markus, 2005). Therefore, individual competition and accomplishment are more valued than collaboration, help and teamwork (Trumbull et al., 2020). This cannot be achieved by the student only; teachers play an important role in supporting the cultural model of independent representations of self. They embody these values and concentrate on rewarding individual endeavours and accomplishments and evaluating group performance based on individual contributions (Fiske et al., 1998, Miyamoto et al., 2018). In classrooms that consider and promote the second cultural model, interdependent representations of self, the approach to learning is mainly dependent on interactions with others (Boykin et al., 2005, Tobin, 1990, Trumbull et al., 2020).

In this case, learning is affected by the strength of one’s connections with others, and by collaboration, trust, mentorship and having a positive relationship with one’s teachers (Cole et al., 2007, Tao and Gloria, 2019). Collaborative learning environments give students the chance to develop positive and trusting relationships in school, which, as a result, create a positive academic outcome.

How are models created? We create models as illustrations of things. These ‘things’ can be ideas about people, places and behaviours. Thoughts about people and their interactions with each other or within the society are generally established on knowledge and belief systems through those interactions. Therefore, we cannot separate knowledge from the knower, although it depends on how knowledge is transferred from one knower to another (Von Glasersfeld, 1989). However, knowledge is an exchangeable and negotiable subject amongst people. This is especially true in the science classroom (Atwater, 1995, Taylor et al., 1997), where students interact with each other, recall memories from the previous year, tell stories about things they have seen on TV or have been told by someone, etc. People across all age groups always exchange stories and experiences; knowledge exchange start in one’s community and then moves to the school. The value of understanding these models, like the
idea that science is hard or boring, is significant. Or, the pressure in some societies dictates that science is for only smart people and is not for everyone.

Science is perceived as a way of figuring out the world and understanding natural phenomena through the tools of observation and experimentation and by trying to find the right answers with proof. Sharing the findings of natural phenomena between the scientists around the world creates a unique scientific language (e.g. atom, DNA, eclipse, plate tectonics). Sharing and confirming each other’s findings becomes a source of debate in the scientific community. The social negotiation of the language and information creates a gap and prioritises Western science over non-Western science because of the power of the dominant language and language forms (Gunaratne, 2009). To reiterate: culture and cultural models play an essential role in constructing people’s ideas and perspectives, and this applies just as much in the science and science education communities. Cultural models help an individual to organise their knowledge, ideas and beliefs towards events and situations which will guide their expectations and actions (d'Andrade et al., 1984, Holland and Quinn, 1987). In the case of teachers, for example, they may share their high expectations with their students; however, many teachers may do so without considering the multicultural viewpoint. Mansour (2009) argues that teachers who do not explore their students’ world are sending out a message that not all students have similar worth and value. However, teachers still struggle to understand the social and political implications of their actions and fail to assess their beliefs, actions and perspectives when executing their beliefs (Ladson-Billings, 1995). There is no doubt that science teachers’ beliefs have an influence on the standards and the quality of science learning in the classroom (Alabduulkareem, 2016).

Quinn and Holland (1987) describe cultural models as relationships, practices and everyday interactions amongst people and the events that develop through repeatedly stimulating our neural networks concerning specific tasks and circumstances. At a theoretical level, cultural models are often implicitly held and are difficult to articulate, even though they generate explanations and perform in the same way as a scientific theory (Quinn & Holland, 1987). However, we can get insights into individual cultural models through judgments, perceptions and descriptions of specific circumstances (D’Andrade, 1992, p. 34). In this sense, cultural models often function as a form of practical reason (Bourdieu, 1990). Cultural models are not fixed rules for performance and attitude; we cannot translate individual behaviour immediately into specific actions. Instead, cultural models have a flexible form that allows us to perform in the world without considering all the possible effects at the same time (Quinn and Holland, 1987). As a result, these models enable us to make sense of complex situations without
requiring every detail to be considered (Gee, 2004). However, these models do not predictably dictate individual behaviour and do not always generate a true meaning. On the contrary, cultural models are regularly inconsistent, incomplete and/or clash with other cultural models (Fryberg et al., 2013, Strauss and D'Andrade, 1992).

The natural dynamic of cultural models is partly the result of different models being closely connected to the environment, such as the size of the classroom. These different models not only stimulate the associated system of schemata, but also establish a part of the schema itself (Quinn and Holland, 1987). Research in the field of cognitive psychology shows that our physical interactions with the world are encoded primarily based on our environmental features; a combination of the environment and pre-existing knowledge shape our memories of our surroundings (Glenberg, 1997). By the combination of the environment and pre-existing knowledge, which we call the cultural model, any situation can help science education to improve science as a whole. These combinations can lead to revealing misunderstandings and misconceptions student may already have, which, as a result, will benefit the relationship young people have with science and with themselves. Next, I will be going to explore the second theory of this study: border crossing in the context of culture, as developed by Aikenhead (1992). The border crossing theory includes five categories, which will each be briefly explained.

3.6. Border Crossing

To explain the border crossing theory, three examples by Aikenhead (1996) will be used to show the difficulties people experience when they move from culture to subculture. In each case, at least one of the people involved does not recognise the need for cultural crossing or the challenges the other person has faced.

1. A couple from North America travel to Spain. They have physically and politically crossed a border, but they have not mentally crossed the cultural borders. They go out for dinner and everything is okay until they ask for the bill, for which they have to wait for 45 minutes. They verbally complain about the lack of service, which confuses the waiter due to his perception of his great service and their unappreciative attitude. The couple expect the service to be the same as back home, as some people think or believe that what they normally do is the normal and a default system everywhere around the world.
Our individual response to this example suggests something about the border crossing work that we have to do in such a situation. Although not situated in science education, this is a very common example of the idea of border crossing between subcultures. Waiting for 45 minutes for a bill was a problem for the couple, for the Spanish waiter, meanwhile, time to relax after the meal is like a gift.

2. A seventh-grade student does not achieve the lab result he expected. The science teacher asks him to explain his answer to her and the rest of the class, and consequently his answer is wrong. The student starts to speak quietly, but no one can hear what he is saying, which prompts the teacher to say ‘you must speak up!’.

In this example, the student has crossed a border physically by attending science class and entering the science room, but he did not cross the cultural border and enter into the subculture of his science class. The student felt very uncomfortable and anxious when he had to express himself on demand to the teacher, without the cooperation of other students. The teacher might interpret his attitude as disrespectful without considering his background. We do not blame either the teacher or the student, because each person has their own perspective about how other people should act.

3. A university student does not follow his university advisor’s advice on enrolling in a geology course. The advisor believes that this student is ‘soft-headed’ and not deserving of a scholarship. In fact, the student does not want to destroy his beautiful understanding of nature’s beauty by learning the scientific explanation for it. This student could easily understand science, but chose not to cross this particular border. The student did not explain his own viewpoint to the advisor, he just decided against the geology course. The advisor might have thought that enrolling in a geology course would open doors for a bright future, or the advisor himself was interested in the subject in the past but did not get the chance to enrol, so, as a result, he thinks the student is making a mistake. Both have their own opinions and understandings of what should be done.

These scenarios point out the difficulties of stepping into another situation and how everyone, despite their gender, age or background, reacts in a different subculture. Everyone’s response is based on his or her own culture model if they do not question the high expectations of their own viewpoint or consider it normal. Moreover, they might get annoyed or irritated if the other person does not understand their own perspective. It is tough to cross over from one domain of understanding and connotation to another (Hennessy, 1993). We often deal with border
crossings in everyday life. In some cases, border crossing can cause a problem, and other times it does not. Border crossings do not need to be obstacles in life. For example, when people who work on a project building a skyscraper leave work to go to a family gathering. Without any effort, they are crossing the border from being a professional at work to being a member of a family and discussing and talking about life. People are always subconsciously modifying their conversations, expectations and beliefs. In other words, they are always crossing the cultural borders between work and family gatherings. These encompass the attitudes and the adjustment of responses in different social situations, which, as explained by Cobern (1996), are a way to convey our preference for universal assumptions.

Border crossings can, however, be difficult and problematic, too. In science education, there is still a debate amongst science educators about the border crossing between people’s beliefs on one hand and scientific theories and evidence on the other. This concern has been raised since novelist and science researcher Snow (1964) discussed this issue in his book *The Two Cultures*. The conflicts that arise from teaching Western science to non-Western students is one of the obstacles that non-Western students face when they move to Western countries. To cope with this, they try to study and implement Western science within the context of their own traditional understanding and background (Baker and Taylor, 1995, Dart, 1972, Swift, 1992, Pomeroy, 1994, Irzik, 2015, Baker, 2016, Lee and Fradd, 1998), which, as a result, creates another problem and, as we all know, people handle challenges differently.

3.7. Borders that students cross

To explore how people move from one world to another, Phelan et al. (1991) created the multi-worlds model. The model includes four types of transitions: the smooth transition, in which the person easily moves between two worlds, the transformation that requires managing different worlds, the hazard transition and the final transition, in which the person is highly resistant of the transition which, as a result, can make the transition impossible. Costa used the multi-world model with qualitative data gathered from 43 students from different backgrounds and attainment levels in science classes and in the world in general (Costa, 1995). The participants were enrolled in chemistry and earth science classes. Costa looked at how students can transfer between their own world and their school world. The diversity of the participants shows there is a particular relationship between students’ world of friends and family and their achievement in science classes and school. Costa defines this pattern in five categories, which will later help to explain some of the data in this paper. The categories are:
Potential Scientists: the worlds of family and friends correspond with the worlds of both science and school.

Other Smart Kids: the worlds of family and friends are compatible with the world of school but not with science.

‘I Don’t Know’ Students: where the worlds of family and friends are inconsistent with the world of science and school.

Outsiders: the worlds of family and friends conflict with the worlds of science and school.

Insider Outsiders: the worlds of family and friends are incompatible with the world of school but possibly are compatible with the world of science.

In the following section, I will present the key features associated with each category of young person, based on my readings of Costa (1995) and Aikenhead (1992).

3.7.1 Potential Scientists

For potential scientists, science classes play a significant role. They see science classes as a way of helping to keep their career aspirations alive. Potential scientists may have a family members or friends doing science, which can be a source of encouragement for them. The aspiration to do science therefore exists both inside and outside the school. They consider themselves future scientists, so they do not worry about any societal classifications. They are open to any challenges they might face. Potential scientists see themselves as potential participants in the science community. The subcultures of school and science are certainly compatible with their subcultures of family and friends, which, as a result, make their border crossings invisible and smooth. The students who aspire to pursue science in the future have support from family members and friends to follow a career path in science. It is not, however, a necessity they have family members or friends working in science fields. The transition between their own world of family members and friends to the world of science and school is smooth. The theory did not suggest that they have to have someone in their family working in science. The question here is whether this smooth movement is smoother when they have someone working in science fields and who is supportive, or it just happened because their family members and friends are educated and value science. What happens if the family is not educated or the relative who works in science is a bad influence? As well, what is the role of the school subculture and the science teacher’s role in the process of movement towards becoming a real scientist?
3.7.2. Other Smart Kids
Other smart kids generally do well in school science classes. However, for them, science has no personal meaning, nor do they think science is useful for everyday life. They do not ask questions about the values, norms and day-to-day actions of the scientific community. Other smart kids prefer to participate in creative activities, self-expression and human interactions. They see science class as more exciting, organised and systematic; it’s about applying facts, making connections and predicting the results, more so than their non-science classes. Science for other smart kids is not part of a primary plan for the future. Other smart kids choose not to do science in future. They see the subculture of science to be personally incompatible with their subcultures in terms of family, friends and peers. For other smart kids, therefore, border crossings into school science are managed without any outside pressure; other smart kids refuse to be encultured in the subculture of science. However, few students view science as a ‘foreign’ subculture.

3.7.3. ‘I Don’t Know’ Students
There are a few characteristics that can help us to recognise the ‘I don’t know’ students. They are usually enrolled in a minimum number of science courses and are generally involved in lower track classes. However, they do relatively well in science. For ‘I don’t know’ students, it is not essential to understand the content as long as they pass the test, which is completely the opposite for potential scientists and other smart kids. Students have learned the game of passing school tests without understanding the content. The ‘game’ has a well-established strategy and students can learn more about the process of the game by listening carefully to the students. The subcultures of science and school are incompatible with the subculture of their family and friends. The ‘game’ has been studied by Larson, who called this phenomenon the ‘Fatima’s Rules’. The Fatima’s Rules show us how students can pass without understanding the subject matter. In the classroom, they do not cause any problems, as long as their teachers do not try to accommodate them within the subculture of science. Teachers should not expect them to replace their understanding and common-sense knowledge of the subject matter. For the ‘I do not know’ students, border crossing is not easy and causes hazard crossing, but they are able to navigate successfully around those hazards.

3.7.4. Outsiders
In the subculture of school, outsiders encounter excessive and unique struggles, struggles that lead to failure, alienation and problems for teachers. For them, the subcultures of school and science are incompatible with the subcultures of family and friends. For outsiders, all
schoolwork is demanding, and they have to conform to school authorities. Outsiders view scientists as experts that are always right, but at the same time, they view them as boring. Outsider know little about the subculture of science, and at the same time, they do not care. Even when science makes sense to them, they do not care enough to hand in homework or study for exams. Some outsiders apply the Fatima’s Rules in order to pass the exams, but most of them do not care, which makes border crossing in school science classes seem impossible.

3.7.5. Inside Outsiders
This group of students are interested in science, but they avoid crossing into school science. School inequities and a lack of support from family members and friend plays a role in students’ avoidance. Examples of insider/outsiders, in Costa’s study, included a number of Afro-American females. The girls were very interested in and curious about science. However, they lacked family support and faced school discrimination, which makes border crossing impossible. As a result, this inhibits them from fully participating in science.

3.8. Caricatures of influence: Identifying the key institutions and influences of young people and the cultural models of science and the real world (and the relationship between them) that are held by those institutions and influences

I created this model in order to identify the institutions and influences of young people. I tried to look at the big picture as a representation of reality that would have value in framing this thesis. Most people involved with education work hard and there is a ton of research that comes out every day to contribute to solving the problems we face in education, and indeed, improving education will improve the country at all levels. We cannot point our fingers at anyone and think we understand the problem and are going to fix it immediately. There is nothing to fix; there are, rather, things we need to consider and start paying attention to. Everyone is working hard; every single person involved in the education process, from the top down, is working hard. If you are a teacher or went to school, you will know that everyone is busy, and if you got a chance to sit with any teacher, you might have listened to them about their struggles, complaints and hard work.

I think we focus too much on the student’s outcomes and overlook their passion about the final product. In my view, we treat the students as products and obsess about making our students
smarter than others and enjoy competing with other schools. We are happy to present and discuss the final results with the heads of schools and we reward and promote teachers who are able to get higher results. There are standards that indicate our level of achievement locally, nationally and internationally. There is nothing wrong or immoral with that, but, by looking closely, we can see how the numbers of the people who chose to pursue science are dropping every year.

The following model was born from the initial data analysis and writing of my thesis. After spending quite a lot of time carefully analysing my data and looking at it through the lens of the cultural model. I want to offer an initial sketch of the factors which influence young people, in terms of the cultural models at work. I am placing this here before the data analysis, as part of the framework for understanding the context of the study in a broader way. Many factors exist, but I chose to work with the following seven features. The diagram will present seven factors that influence young people. I will introduce each factor’s vision or, in other words, its cultural model. In doing so, I am going to present something of a caricature: a picture designed to bring out some key features, rather than strictly aiming for a one-to-one relationship with reality. The seven factors are:

1. National education bodies
2. Educational institutions
3. The science classroom
4. Friends, classmates, peers, social media and the internet
5. Family and community
6. Society
7. The student

3.8.1. National education bodies
There are two types of departments of education in England. The first is ministerial education, which is supported by 19 agencies and public bodies and non-ministerial departments. They are responsible for providing a high standard of teaching to all children from an early age to the highest education level. They also deliver professional development instruction to everyone who works in education, through traineeship, for example. This type of education helps disadvantaged children and young people to reach their goals, protects local services and support children (Education and Learning, 2020). As I stated earlier, I will use the visions of each factor as cultural models. The Department of Education’s vision is as follows:
Our vision is to provide world-class education, training and care for everyone, whatever their background. It will make sure that everyone has the chance to reach their potential, and live a more fulfilled life. It will also create a more productive economy, so that our country is fit for the future.

The vision and goals of the Department of Education are well written and it is easy to see how they apply in the real world. There are organisations funded by the government to improve education and make sure this vision is achieved. For example, the Ofsted organisation is responsible for inspecting and regulating educational institutions to make sure they meet governmental standards. For science specifically, there is the Association for Science Education (ASE), which is the largest subject association in the UK. It is independent of government and registered as a charity. They are an active membership body which supports science education teachers and educators from pre-school to higher education. They aspire to be a powerful voice for science education professionals and inspiring and develop the knowledge of science teachers and technicians in order for them to deliver an excellent performance. Ofsted and ASE have the opportunity to improve education but, from what I see and understand of the Department of Education, Ofsted and ASE, they each have their visions and goals to achieve. Each of them has their own cultural model and ideas about how things should be done. In other words, each organisation is dominated by a higher power and their individual cultural models, and, yet, we know nothing about the people who make the rules and what vision or culture models they hold. Each group is led by experts and professionals and the goal of each is to build upon their experiences and research findings, however, by closely looking at each organisation, it is clear that their goals are different. Research suggests that science in school these days is taught using a national curriculum that repeatedly reinforces conventional images of science, such as the fact that science is ‘socially sterile, authoritarian, non-humanistic, positivistic, and absolute truth’ (Matthews, 2021). That means ‘one size fits all’ regardless of the visions and goals of others. This is relevant for future research, which should seek to understand the conflicts and challenges each group faces in order to implement their visions and then achieve and record those successes.

3.8.2. Educational institutions

Educational institutions provide a large space for learning and create a variety of learning environments for people across all age groups and with different levels of access to education, for example, preschools, primary schools, secondary schools and universities. Schools aim to offer learning spaces and learning environments in order to teach students. It helps children
become productive citizen by using their knowledge, talent and learning skills to improve themselves and help others. There is an understanding and culture about what, how and why school exists. As previously reported in the literature, there was a time when science was restricted or limited to one social class (Mendelsohn, 1976; Rose, 1994; Simonelli, 1994). Everyone has their own understanding and cultural model about how the school should function and what purpose it serves. Generally, everyone is concentrated on student outcomes and school reputation and the scores students earn from inspection. From my point of view and my experience, there is a lot of focus and pressure on everyone working at schools, which leaves no time to understand and listen to our students.

I am going to discuss three major roles that, in my opinion, influence the school cultural model.

A) **Inspectors.** They come from outside schools and are responsible for evaluating the whole school system to make sure it delivers an outstanding learning environment and government requirements. They use a cultural model of how everything should look like, and they follow a framework of how things should be run and what makes schools outstanding. They apply the same framework for all schools and ignore how what might be done in a high-performing metropolitan school is hard to attain in suburban schools full of immigrants, children working class families and a mix of ethnicities. In England, the inspectors are from the Ofsted organisation I mentioned earlier. After they are done inspecting a chosen school, they publish an official report of their findings and the overall quality of education and training in schools. The results of the evaluation can be found on the school’s website or on a signboard outside the school.

B) **Supervisors.** By ‘supervisors’, I mean the heads of each department in schools. They are responsible for managing, assessing and improving their departments to ensure they reach the highest level of achievement in all activities. They assess the teacher’s performance and they desire to improve student performance to meet inspectors’ requirements and increase their schools’ standing in comparison to other local schools. To do that, they abide by their own cultural models, which might be different from what teachers believe and think; in other words, teachers’ cultural models.

C) **Teachers.** The people who plan and create lessons and teach them to the entire class. They track students’ progress and present information when needed. Teachers also
create tests and analyse the results and they also work with the administration and parents in schools at all levels. Teachers are under pressure all the time to prove themselves and meet supervisors’ and inspectors’ expectations. Every teacher holds their own cultural model about how things should be done, but they ignore that voice because they are too busy. Supervisors and inspectors often assess teachers to make they deliver high-quality lessons according to their own vision and way of understanding, but the main focus and the final word is always the student test results.

3.8.3. Science classroom

Science class is a great opportunity for students to understand how and why things work the way they do. Science lessons offer a great chance to improve the most essential skill for students, which is critical thinking. With science, we are able to explain the reasons behind the function of everything. The school we did our research in was adapting its laboratory design, with the teacher at the front of the classroom and the students sitting in a group around benches. It was decorated by a bulletin board to display some science information, including posters with vocabulary and a 3D solar system model, the Periodic Table and more. Decorating science classes with visual representations of science is part of the culture we grow up with and which continues until today. I am wondering if eye-catching science class decorations make a difference. I think students who help create science class decorations may feel excited about it because they are already interested in science and therefore are happy with the decorations, but what about students who do not care about and are not interested in science? If decorating the science classes changes their opinion, I assume that, after a short period of time, the students will still forget about the class decoration. Apparently every science department in schools contains this cultural norm of decorating science classes; will that really inspire students to love science and enjoy it and be a part of it?

Science lessons are supposed to be an environment to encourage students and inspire them to do science, but, instead of that, science lessons have instead become a massive weight on student’s shoulders. For instance, in physics classes, students who are from underrepresented backgrounds tend to go unnoticed, while marginalised students get more attention and encouragement, and such students will do well in science exams and enter science-related careers (Rifkin, 2016). This is an issue that we must address as well. If you observe science classes today, you will find that some students are busy doing something related to the lessons like filling in missing pages in their notebooks, while other students distract themselves with
something unrelated to the lesson. To be clear, I am not talking about the teacher’s ability to manage the class or create an interesting lesson. Teachers work very hard; they try to apply their knowledge as best they can to get students’ attention and engagement. While teachers are often busy delivering lessons, science teachers mostly rely on videos rather than doing actual experiments. They are busy answering questions, referring to the exercise books, managing the class and making sure everyone is following along and engaged, either writing from the board or solving an exercise she is already giving them. On the other hand, students are also busy working on the teacher’s requirements and corrections. Some of the pupils move around to help others and the social life of the classroom is great but the question here is whether this atmosphere contributes to them achieving their future visions for science. Science teachers are dedicated and work hard to match the school expectations, but the longer term outcomes for young people are not really discussed.

3.8.4. Friends, classmates, peers, social media and the Internet
A significant and growing body of literature has investigated peer effects. Not much is known, however, about the role of the friendship and social interactions on students’ results. According to Burke and Sass (2013) they play an essential role in discipline and disruption. Recent evidence suggests that friends can have a fundamental influence on students’ results, but in many cases, the impact of friends seem to be independent of overall peer effects (Burke and Sass, 2013). From my perspective, those influencers that surround students most of the time each have their own understandings and views of science, which present as cultural models. For example, friends share their own feelings and understandings regarding the expectations of teachers, like how to push towards exam performance. As well, when it comes to classmates that might they not be friends outside the class, they still attend the same classes and share the same spaces and do activities and experiments together. Each classmate has his or her own cultural model for understanding the importance of science and their own view of whether they enjoy science classes or are just doing science because it is important and they have future goals related to science. Each student has his or her own cultural model of what science is and why he/ or she is studying it. Every one of our students has their own cultural model and shares it with others by publicly talking about it or implicitly sharing it through their actions. A common cultural model held about teenagers is that they sensitively and quickly adapt to each other’s perspective. The cultural models of friends, peers and the internet therefore definitely play a role in young people’s perspectives towards science.
3.8.5. Family and community

Family has a significant influence on student life. I use the word ‘family’ here to refer to people who surround students at home, including parents, guardians, siblings and other family members. Each of them has their own cultural models, experiences, expectations and understandings of science, which might have a considerable impact on a student’s academic life in three ways: encouraging students to pursue science or add more pressure to meet expectations or to believe that science is a difficult and boring subject that is not easy to enjoy or achieve a high score in. All family members have an influence on students’ lives and beliefs in regard to science; they are the first informal education the student ever receives before their formal education starts. Students spend most of their time interacting and observing their parents and community. Family members are the first people who open children’s eyes to future opportunities and inspire them about what they want to be.

Different cultures have different aspirations and cultural models. From an Asian cultural perspective, becoming a doctor is what many people try to inspire their children to do, no matter whether that is what the children want or not – see literature review (Markus and Kitayama, 2010). This approach does not consider the children’s interests and abilities in relation to science. It puts a significant pressure on students. I remember hearing the phrase ‘they all want me to become a doctor or lawyer’ from every single student in the science department in the research school, which I heard as well from some of the participants when I asked what they aspire to be in future, regardless of their attainment levels.

3.8.6. Society

Society also influences students’ perspectives and understandings of science. Society plays a vital role in increasing people’s awareness of and emphasis on the importance of science. Society’s cultural models can be seen in the way that society emphasises scientific issues and promotes knowledge about environmental problems, health or any other aspects. Society’s activity in terms of science is the most significant example of the cultural models that establish the relationship between science and the real world in everyday life. It shows what is acceptable and not acceptable from society’s perspective. Scientists who have grown up and lived in the same area can be an inspiration to them to value and pursue science in the future. Society’s cultural models of science can be seen in advertising signs on the sides of roads and activities in the neighbourhood (sports, public events, park life, etc.) and, also, in charity work (within businesses, shops, hospitals, other institutions, etc.) and religious institutions, transportation organisations and environmental groups, which all have an influence students’ understanding
of science in relation to themselves and the world. As previously discussed in the literature review, the field of cognitive psychology demonstrates that our physical interactions with the world are internalised primarily based on our environmental characteristics; a combination of the environment and pre-existing experience form our memories of our surroundings (Glenberg, 1997). I am from a small rural town in Saudi Arabia and, until a visit last month, I never saw a single sign promoting science. However, we do have ‘Tree Week’, which is an event that must take place in every school and requires students to plant a tree. The idea behind this event is supported by students’ religion, as planting trees is regarded as an act of charity. As a result, you will find posters around the city and in mosques and schools promoting this initiative. This event shows the importance of nature and young people will appreciate nature from a religious viewpoint, however I assume it does nothing to encourage young people to pursue science.

3.8.7. The student

All seven factors have an influence on students’ understanding of science and how likely students are to identify themselves in relation to science. Each one of these factors contains its own cultural models and an understanding of the way that science must be taught and studied. Each of them has its expectations and goals. There is an extensive literature about each of these seven factors and there are many studies that have been done to improve science for all, as STEM fields play an essential role in the economy. Most of the investigations about these factors ask students a list of questions and involve either waiting for an answer or observing students for a while. A more comprehensive description about the projects that have been done in the UK can be found on page 15. In this model, I asked students to picture what they think about when they think about science and how science is related to their everyday lives. I tried to listen to the students’ voices, which do not entail what we might think it does – many of the students describe how they struggle in science, which is what really inspires them to do science.

Family, community and society impact students’ perspectives on science before they ever reach school. Are we, as science educators and curriculum developers, considering those features? Participants’ lack of knowledge about future options was significant. Every school is focused on the process of teaching and the end-of-year results. Everyone is busy with their own expectations and no one has enough time to stop and analyse what is really going on with students. The assumptions teachers made about all students wanting to be doctors or forgetting experiments immediately and being ‘too lazy’ do not appear to be fair, in my experience. The
science classes were great and the teachers work very hard, but, based on my investigation, science classes can often be boring for students and not related to students’ everyday lives.

On the next page, I have designed a diagram to illustrate these seven factors in order to understand why young people these days are struggling and not interested in science. I have placed the diagram here in the theoretical framework chapter as a way of introducing key features of the context of the study.
Figure 2. The key institutions and influences of young people and the cultural models of science and the real world (and the relationship between them) that are held by those institutions and influences.

The above diagram contains circle and arrows; the circles show the cultural model and the arrows present the direction of these influences. The diagram begins with experts’ and researchers’ cultural models, which influence education departments. The capital of education has two cultural models: one for the school, about how schools should function, and the second which is directed towards the students and which is meant to be the standard that students should meet. Notably, there is no arrow coming from the students, like official feedback or opinions that go directly to the researchers or curriculum developers or to the department of education. When young people are given the chance to pass on their feedback and views, it
must go through imprecise filters, like the cultural models of anyone who delivers those opinions. The schools also have two cultural models, schools involve the supervisor, the teacher and the examiner, and every one of them has their own cultural model. Those members do not share their cultural models. Everyone follows the vision of the school, which was established by the department of Education or by their school and which is based on how the classes should be organised and taught and also on the percentage of participation in the classroom and exam results. The second cultural model is about the students and what schools expect from them; again, here, no arrow comes from the students to the school.

The culture model about the participation rate, the exam results and the classroom organisation, and teaching methods is influenced by students’ relationships with science and with the education system as a whole. As well, the cultural model of friends, peers and classmates in relation to science influences young people unconsciously. In addition, young people these days experience a lot with media content, which will impact and influence their relationship to science. It is dependent on individual interest and, so, it may either inspire them to love science or see science as a difficult subject. As a result, students will carry those impacts to their family and share what they heard from friends or watched online with their family members. Family members also have their own cultural model of science and whether it is important or not. Meeting family expectations is necessary in some cultures, which can leave students feeling lost and like they have no choice. Even in their own family, young people sometimes have no voice when it comes to choosing their future or whether they are interested in science, since no one from their family is supportive. Lastly, there is the cultural model of society, which influences the family and community. Society has the power to nourish young people’s relationships with science, depending on the cultural model of their surroundings. I believe in the power of society to raise the entire community’s awareness about any topic.

These seven factors were the ones that I noticed while conducting my study and I believe they have an unconscious impact on the whole system. The absence of the voices of young people in terms of developing the educational experience is enormous. We do not listen to our students unless they are stressed and not doing well on their exams. We do not know much about the misconceptions caused by their own cultural models or why they abandon science as a future prospect. Studying each factor in the cultural model has the power to effect great change; each group has its own requirements and goals. The missing piece of the puzzle is that no one considers young people’s cultural models and the challenging borders they have to cross to meet those goals.
3.9. Summary

Border crossings into the subculture of science for the five groups of students described above are smooth, manageable, hazardous or virtually impossible. It is not possible to classify individuals based on which group they belong to. However, by knowing the cultural models that young people grew up with and are surrounded by, we might be able to help individuals cross the border smoothly. Exploring the concept of cultural models and border crossings led me to draw new models in the hope of understanding the relationship between science and young people. The result of not being heard and unconsciously following and believing other people’s opinions created a gap between young people and science. There are undeniable influences that affect young people’s perspectives on science without them noticing.
CHAPTER 4
Methodology

4.1. Introduction
This chapter will discuss the photo elicitation interview (PEI) technique from a theoretical perspective. Photo elicitation interviews are considered part of a broader scope of visual methods issued in the social sciences. The chapter will begin with a brief description and discussion of visual research methods followed by a more detailed discussion of the PEI method as a qualitative approach. The chapter will then explain in detail, step by step, what was involved in conducting this research. It will describe the research site, the potential participants, the participant selection criteria and the PEI setting and will also describe the use of some supplementary approaches to generating data, such as surveys and observation.

4.2. Visual research methods
This study mainly relies on photographs and uses PEI as its primary research method. We are, therefore, focused on exploring photographs in the literature. Recent academic attention has focused on the provision of visual methods in the health sciences (Fraser and al Sayah, 2011), the social sciences (Gubrium and Harper, 2016) and education (Mitchell, 2011). For more than 30 years, researchers have been developing visual methods with the aim of enriching qualitative research (Packard, 2008). Breaking down the power imbalance between researchers and participants is one of the most influential benefits of applying visual methods (Hurworth, 2004, Pink, 2001). Visual methods have been used to document the research process, as motivation for producing further data and also as research evidence (Rose, 2016). Visual methods have not only been used to obtain information, but also to reflect on stereotypes and on the practice of power in communities, as well as to access and strengthen social benefits (Banks and Zeitlyn, 2015).

Visual methods in general were first used by early colonial researchers to document the lives, physical attributes and cultures of native or indigenous peoples (Collier, 1957, Collier and Collier, 1986, Harper, 2002, Pink, 2001), and were used mainly to support existing theory and the authors’ perspectives, rather than to generate new theory and research (Harper, 2002). The use of photography in research has been documented in several approaches. According to Holm (2008), there are three major categories of research that use photography. Firstly, there is the ‘subject-produced images’ approach, in which the
researcher asks participants to photograph features of their lives. Secondly, there is the ‘researcher-produced images’ approach, in which researchers themselves document experiences or settings. Lastly, there is the ‘pre-existing images’ approach, in which existing, sometimes historical, photographs are used. Much of the recent research involving young people and photography has depended on subject-produced images, such as photo elicitation (Dockett et al., 2017).

Moreover, photo elicitation has been used to advance movements or political agendas. Non-participatory visual methods, in which participants respond to photographs provided by the researcher, have also proven to be effective in creating a bond between researchers and participants and creating a ‘comfortable space for discussion’ (Epstein et al., 2006, p. 8). This method of photo elicitation was first developed and explored by John Collier in the 1950s; he compared photo elicitation interviews with conventional interviews in his study of the environmental basis of psychological stress. Collier concluded that:

_The characteristics of the two methods of interviewing can be simply stated. The material obtained with photographs was precise and at times even encyclopaedic; the control interviews were less structured, rambling, and freer in association. Statements in the photo interviews were in direct response to the graphic probes and different in character as the content of the pictures differed, whereas the character of the control interviews seemed to be governed by the mood of the informants._ (Collier, 1957, p. 856, cited in Harper, 2002).

According to Collier and Collier (1986), photo elicitation formed longer and more in-depth interviews, without the boredom of traditional interviews. Since Collier’s findings were revealed in his book _Visual Anthropology_ in 1986, his approach has been widely replicated by researchers. The use of participants’ photos also sheds light on people’s ‘real lives’ (Berland, 2007) and also improves the quality of the communication process (Fleury et al., 2009, Harding et al., 2009, Gates et al., 2001). Participatory photography has also been established to aid in policy-making processes (Lorenz and Kolb, 2009) through the vocalisation of the often-vague opinions of community residents, service users, children and other vulnerable or marginalised groups (Wang and Burris, 1997, Wang et al., 1998, Strack et al., 2004, Cooper and Yarbrough, 2010, Duffy, 2010).

For this study, photo-elicitation is the primary methodology. As an example of qualitative research, this study is intended to examine the further use of photography to elicit young people’s perspectives on how they connect their surroundings to science. Before describing how this was achieved in practice, I will focus in detail on the particular approach adopted in the study, the photo elicitation method.
4.3. The photo elicitation interview method – qualitative approach

The term ‘photo elicitation interview’ (PEI) is used in photo elicitation research to describe interviews in which participants explain the meaning behind their photographs in the form of a commentary delivered to the researcher (Harper, 2002). Photo elicitation is simply the use of photographs to generate verbal discussion (Thomas, 2006). The photograph can be generated by the participants or by the researcher. Photo elicitation is now a broadly- and frequently used technique in which researchers present cues to participants’ and ask them to comment (Glaw et al., 2017). Photo elicitation generates a different kind of information; it is like a trigger for emotions, feelings, past experiences and memories (Harper, 2002). Many studies invite young people to take photographs of their everyday lives and then discuss it with them (Clark, 2001, Clark and Moss, 2005, Dockett et al., 2012). A common rationale for using photo elicitation is that it presents an opportunity to encourage young people to engage with the study and also opens up novel and interesting aspects that contribute to the research (Dockett et al., 2017).

A key feature of photo elicitation is using photographs in research discussions. The photograph needs to have been taken or provided before the discussion begins; following the discussion, the photographs and stories are shared with an audience (Wang and Burris, 1997). Dockett et al. (2017) claim that many photos elicitation research projects pay less attention to the ‘sharing with an audience’ stage and, as a result, the sharing of findings is limited to other researchers and research publications. The main difference between traditional interviews and the photo elicitation interviews is the way that participants respond to symbolic representations in photographs. Interestingly, the part of the brain which responds to visual information is, in evolutionary terms, older than the part of the brain that processes verbal information. Therefore, visual images evoke a deeper part of human consciousness than words do (Harper, 2002). Words alone use less brain capacity than the processing of visual representations using one’s words (Harper, 2002). This is why photo elicitation interviews are not merely interviews. PEIs are more effective than traditional interviews in terms of obtaining more and different information during interviews (Harper, 2002).

PEIs allow researchers to discover a hidden layer of meaning. The process of letting the participants take their own photographs gives them the freedom to choose what they want to talk about during the interview, which, as a result, makes the participants’ more relaxed.
Participants are also more relaxed because they know the content of the interview in advance, are allowed to decide the order in which the photographs are discussed and are allowed more control over the direction of the interview (Noland, 2006). Harper wrote that:

*Photo elicitation may overcome the difficulties posed by in-depth interviewing because it is anchored in an image that is understood, at least in part, by both parties. If the interview has been successful, the understanding has increased through the interview process (Harper, 2002, p. 20).*

PEIs can contribute to the participants and the researcher finding a common understanding (Harper, 2002). During the PEI, the researcher can observe the participants’ emotions as they arise while talking about the meaning of the photo. The participants may also bring up perceptions that are not necessarily explicit in the photograph. The PEI method allows for triangulation between different data sources and can also bring diverse viewpoints to the research (Glaw et al., 2017) and, consequently, ensure it is comprehensive. Photo elicitation can add additional logic, validity and depth, new opportunities and new perspectives (Glaw et al., 2017). PEIs can generate more in-depth and interesting discussions. PEIs are a form of collaborative work between participants and researchers; they are not the result of the individual efforts of the researcher alone. However, researchers can still draw out and construct what they need from the interview. As well, the participants can frame and formulate their responses and, therefore, photo elicitation can be a form of both data generation and data analysis. Researchers who use this method have found the emotions and the meaning they obtain can differ from or add to traditional verbal interviewing techniques.

PEIs have been successfully applied in a range of studies (Mannay, 2013), including interviews with children, where traditional verbal interviewing methods created limitations (Epstein et al., 2006). Photo elicitation has also been used to study social, racial and peer groups in high schools (Glaw et al., 2017) and in Maasai villages in Tanzania, where researchers investigated the use and preservation of natural resources (Bignante, 2010). PEIs have been used in studies on children, families, universities students, farmers, substance abusers, those with illnesses and different cultures and ethnic groups, and in studies looking into the social identities of children, the importance of clothing for adolescents, the work environment (Harper, 2002), in parents’ experiences with long-term distress after the preterm birth of a child (Kantrowitz-Gordon and Vandermause, 2016), and in visual autobiographies (Harper, 2002).
PEIs have been used to provide links and understanding of the cultural models held and used by others. For many years, Collier and Collier (1986) used visual anthropology (photography) as a research method. They used PEIs to explore topics such as religion and to allow participants to convey joy and aspirations, the psychological difficulties of life and different cultural practices, which, as a result, helped them to achieve a better understanding of different cultures. PEIs open up the possibilities of communication across different cultures, and, therefore, provide links to other cultural models. PEIs have also been used to research businesses, workplaces and power struggles, children and their engagement in education, cultural and linguistic minorities, social relationships and social structures, cultural ceremonies and urban versus rural living. The use of photographs allows researchers to elicit new information that is has not been previously expressed or captured (Steger et al., 2013). In the past, PEI research relied on traditional verbal methods, however not all participants have great verbal skills, even though those who participate may still find it hard to articulate what they want to say. PEI generates productive, illuminating responses and more profound thoughts and feelings, which allows researchers to detect understated meanings in their participants’ responses. Allowing participants to clarify what they genuinely intend to express about their photographs increases the trustworthiness of the findings through member checking. This demonstrates that, by going beyond written and verbal responses, there is a lot of potential for photography to be used in almost any population so that the participants can share their worlds. These populations may include the poor, migrants, the homeless or the illiterate, who could be more readily studied using this method to obtain a detailed picture of their unique experiences (Steger et al., 2013).

There are both benefits and obstacles to using PEI data. On the one hand, photos can contain a vast amount of data regarding the individuals, in areas that are personal to the participants. On the other hand, participants may take superficially unrelated photos (Epstein et al., 2006), useless photos (Packard, 2008) or unintentional photos that can confuse assumptions derived from the visual analysis. Orellana (1999) instructs researchers exploring photos ‘not to over-psychologise our interpretations of photographs, and of the importance of listening to the photographers talk about their work’ (p. 86). One of the benefits of the PEI technique is that the interviews allow researchers to access a part of the participants’ reality that otherwise might have been inaccessible, such as their perspectives and attitudes. To do this, researchers use a semi-structured interview protocol and probes (Patton, 2005).
Moreover, photographs can promote a conversation around topics/issues that are taken for granted by, or are invisible to, the researcher (Guillemin and Drew, 2010), which accords with Collier’s (1957) study cited above. PEIs can also enhance young participants’ concentration span and hold their attention for a longer period of time (Dedding et al., 2012). The photographs sometimes facilitate things that are hard to explain using words alone. Photographs can also diminish potential verbal barriers, trigger memories and evoke unpredictable data (Dedding et al., 2012, Hurworth, 2003). Using photos is fun and enjoyable for young people and does not involve any particular skills (Punch, 2002). As well, photographs are likely to evoke information, feelings and memories that might not come up otherwise. They also position the participants as experts within the research process (Rose, 2016, Clark-Ibáñez, 2007). Photographs can act as a shared focus of concentration for dialogue, as well as an anchor (Barthes, 1964). They can also provide a basis for consideration, interpretation, explanation and re-explanation (Harper, 2002). Both the photographs themselves and the discussions they inspire shape the data gathered from PEIs. There continues to be a tendency among researchers, however, to concentrate on the content of the discussions and only occasionally view the photographs as symbolic (Rose, 2016).

One of the challenges researchers face when using PEIs in research is that they must reduce logistical issues while also tackling worries about reliability and validity. Other challenges include logistical issues, such as the extra cost of buying cameras and developing photos. This obstacle may possibly be solved by permitting participants to use their own camera phones for data generation instead of buying cameras, or by using physical prints and later cataloguing the photos as digital prints instead. Providing access to cameras is often referred to as a common logistical concern of PEIs. Frequently, participants are given a camera and either do not take photographs or become no longer be accessible for an interview (Allen, 2009). This obstacle increases the cost of doing PEIs and diminishes their reliability and validity (Clark, 1999).

Another example of the complicated obstacles researchers face in terms of the use of cameras is evident in a study by Packard on homeless people’s lived experience. Packard (2008) found that because of the participants’ lack of practice in using cameras and taking photos, many photos taken by the participants were useless, because they were unfocused or because the photographers’ fingers were blocking the subject matter (see Packard, 2008, p. 70, for example). Moreover, when Bunster (1977) performed a traditional PEI with Peruvian market women, he found some women had never seen photos themselves and, therefore, needed help taking photos. Other researchers have noted that participants sometimes do not remember to
take pictures at regular times and, therefore, either return an unfinished roll or end up taking many photos of the same subject matter all at once (Packard, 2008). Alternatively, participants may lose their cameras and come back with no pictures to share (Orellana, 1999). The solution to this problem is to offer training and send notices to participants reminding them to take photographs during the study.

Doing a PEI may raise issues of reliability and validity because the data generation is controlled by participants. Participants may be prone to taking pictures that are socially appropriate and hide potentially essential parts of their experience, or they may take pictures that they later regret and then remove their consent for use of the photos. This can be particularly challenging when researching young people in schools. (Biag, 2014) found in his study that, when young people were being marked on their participation, the validity of the outcomes may have been reduced. The feeling of discomfort caused by the presence of a camera (for the participants or people around them) may also make taking pictures hard.

Another frequent threat to the reliability and validity of PEIs is the limitation and restriction about what participants are allowed to photograph. Young people in schools may be restricted in terms of the zones and individuals they are permitted to photograph, and all PEI participants are likely to miss out on chances to take relevant pictures at times when their cameras are accessible or when they are in awkward or vulnerable circumstances (Clark, 1999, Richardson and Nuru-Jeter, 2012). Young people may also feel constrained in terms of what they should photograph by their parents or other adults who encourage or ban them from taking pictures of certain people, locations or items (Clark-Ibáñez, 2004).

Regardless of these restrictions, some authors claim that the PEI technique increases the validity and reliability of data they obtain because the photos can be triangulated with data gathered in interviews or via observation (Harper, 2002, Agbenyega, 2008). Using photos in interviews offers unique perspectives on specific features that participants may wish to illustrate. In an example by Steiger (2000), a participant explained her house as having a ‘large room’, which could indicate very different things to different people without the aid of a photograph. The photo confirms that the researchers and the participant both recognise the size of the ‘large room’ in a similar way.

One of the obstacles that researchers must consider is the ethics of using visual methods. Ethical issues can occur when conducting auto-driven interviews (Joanou, 2009). There are some concerns about participants not being completely aware of how their photos are going to be used (Shohel, 2012). As well, there is a concern that photographs that obviously identify participants can be used illegally (Orellana, 1999). In addition, photographs may reveal the
identity of non-participants who have not consented to being part of the research experiment. Furthermore, there is a concern that researchers will be in a position to manipulate marginalised participants, such as children, into exposing data about their lives that they may perhaps not truly want to expose or that may result in negative outcomes for them (Zartler and Richter, 2014). In general, researchers have to face these ethical concerns by clearly explaining to participants how their photos are going to be used and, also, by making participants sign consent forms, redacting the identities of people shown in photos or not using the photos in published works (Allen, 2009, Orellana, 1999, Meo, 2010). On page 95 we will discuss the ethical issues of using visual methods in research and which approach we followed to overcome these concerns.

4.4. Power dynamics in visual research methods

In social sciences research, many studies emphasise how the power dynamics between researchers and participants is unequal. In an example given by (Harper, 2002), it was pointed out that while the researchers were investigating the lives of homeless people in San Francisco, the homeless could not, in turn, investigate the lives of the researcher. It is essential to consider the role that power plays in the relationship between researchers and participants in any study involving children or young people. Many studies that tackle power issues are related to research involving young people (see, for example, Christensen and James, 2000; Fraser, Lewis, Ding, Kellet and Robinson, 2004; Lewis, Kellet, Robinson, Fraser and Ding, 2004) (Fraser, 2004). Given the variation in age between the participants and the researcher in this study, power dynamics-related concerns were recognised and the existence of such concerns informed the methods implemented and the study strategy (Fraser, 2004). This research requires that young people be active research participants and the choice of a photo elicitation interview technique, in which students generated their own photographs, supports and reflects this standpoint. Researchers who support photo elicitation interview methods do not argue that this method reduces issues of power dynamics in research. However, they claim that using photographs in research disrupts some aspects of the power imbalance of more traditional research methods. It has been claimed that disrupting the imbalanced relationships that are deeply rooted in traditional research encourages the narrative accounts provided by participants.

The ‘opening up’ of the interview situation and the alteration of the balance of power between young participants and researchers in this study was found to be a significant strength of the
photo elicitation interview method, one that might improve the engagement of the participants. In particular, altering the balance of power allows the research to be more participant-driven, and a participant-driven method is essential when exploring young people’s perceptions of science.

The presence of photos in the research setting also disrupts the power dynamics that are deep-rooted in the research process. Photos provide both the participant and the researcher with something to focus on and, thus, they ease some of the awkwardness and discomfort that may exist in purely verbal interviews (Clark-Ibáñez, 2004, Collier, 1957). The age difference between the researcher and the participants also contributes to an unequal power relationship and, therefore, a calm interview atmosphere was essential. Pyle (2013) and Briggs et al. (2014) claim that perhaps one of the reasons why photo elicitation methods have been used successfully in studies involving children and young people is because they disrupt the traditional power relationships between the researcher and research participants.

4.5. Ethics in visual research

The use of visual methods in research necessarily requires discussing important issues related to consent, confidentiality and anonymity. Although these issues may have some similarity to issues that arise in non-visual methods, visual methods do raise specific challenges (Rose, 2016). Many of these are related to the photographic content itself, which may reveal the participants’ identities (Wiles et al., 2008). This can be solved, however, by instructing participants not to photograph any people, including themselves. While the school itself is identifiable to those familiar with it, pictures that might have made it possible to identify individual participants have been eliminated.

Few photo elicitation interview studies discuss the ethical issues associated with the technique. However, Wang and Redwood-Jones (2001) addressed ethical issues associated by using ‘photovoice’, which is one application of photo elicitation. Although Wang and Redwood-Jones’ research took place in an American setting and within a different context, the challenges they confronted were applicable to any discussion on photo elicitation interviews and ought to be considered in any context. Informed consent is a fundamental step for all research involving human participants. From Wang and Redwood-Jones (2001) view ‘photovoice’ project elaborated on three types of consent: consent from the participants to participate; consent from participants to use their photographs; consent from any subjects that might be represented in
the images. In each case, consent from the participants’ parents/guardians was also obtained, as the study’s participants were all minors.

Another ethical issue that can arise from the use of visual methods relates to ownership, authorship and copyrights. The participants are the legal owners of the photographs, which means that their consent was needed for the reproduction or display of any of the photographs (British Sociological Association, 2006).

The participants were asked to consent to the use of their photographs by the researcher for data generation, data analysis and dissemination. They were informed about the possibility of displaying some of their photographs during conference presentations or within journal articles. However, beyond this, the issue of who owns the photographs was never formally discussed and they were not asked to enter into a formal copyright agreement for any of the photographs. The status of the photographs is as data within a research project, rather than as pieces of art.

Ethical perspectives about the inclusion of photographs in the research process must be considered. I followed a principle-based approach, which, according to Wiles et al. (2008), comprises four aspects: autonomy, non-maleficence, beneficence and justice.

1. Autonomy: participants must be free to make their own decisions about their involvement in the study.
   At every stage, we kept reminding the participants they were free to leave the study. We made sure they understood that participating in the interview was voluntary and that they were not getting any extra credit for their involvement.

2. Non-maleficence: the research must not impose any harm on its participants.
   The main focus of the research was to understand young people’s perspectives on science and to explore their relationship with science. No personal questions were asked, even about their attainment level or their relationship with the science teacher.

3. Beneficence: the research should be of benefit to others.
   The research is motivated by the gap between science and young people. The benefits derive from that, and go towards helping young people, teachers and curriculum developers. The research empowers young people to share their unspoken perspectives on science.

4. Justice: participants must be treated equally within the research process.
   We interviewed the participants in pairs to minimise the power of the researcher. We also made sure each participant had enough time to discuss their photos. Participants were given
the power to take the lead in discussions and to select what they wanted to share with the researcher. As recommended by Mandleco (2013), the discussions took place in a quiet room to prevent interruptions and to guarantee confidentiality. Moreover, participants were guaranteed that their identities would not be linked to their responses or to the photographs they took and that what they said would be anonymised and securely kept on encrypted devices. At each stage, the participants were asked if they were happy to carry on before proceeding. They were also reminded that they were free to withdraw from the study at any given time without any justification required. The research was approved by the University of Manchester’s Research Ethics Committee on the basis of the protocols and considerations discussed here. (See Appendix 1).

Pilot study

In order to evaluate the photograph guide accurately and to ensure it would meet the needs of the research, a pilot study was conducted using Samantha, 14 years old and Rana, 16 years old. The photograph guide and digital camera were given to them for a week. Following this, an interview which lasted for about an hour was conducted. The purpose of the pilot study was to explore the length of the interview and whether the PEI method is feasible and acceptable. The basic underlying context according to which the results are presented aligns with the research concept. Essential adjustments to the photo guide and the interview guide were made based on the pilot study (see Appendix 15 for Samantha PEI).

The pilot study results were very interesting, as they revealed that the real world is different and has little connection with science. From the viewpoint of Samantha, science is everything made by man while the real world consists of the creatures made by God or Mother Nature. Samantha’s father was asked if he was aware of the view held by Samantha; he said: ‘I had no idea about this and when she talks about science she just keeps saying that science is BORING’. Through doing this research, it was expected that such surprising results could help science teachers and curriculum developers improve the quality of science teaching and make science more relevant. Considering the mix of ages, attainment levels and backgrounds of the participants, it is anticipated that this research will produce some highly interesting and useful results.
4.6. Data generation

In the previous section, the concept of photo elicitation was introduced from a theoretical perspective. Next, I will describe how the study was conducted and what data was generated. This section focuses on three aspects: the setting the research was conducted in, the data collection phases and an analysis of the data.

4.6.1 The research setting

Data generation for this research occurred between January and June 2017. The research was conducted at a girls’ secondary school in the northwest of England. Participants were in years seven, eight, and nine (aged thirteen to fifteen years old). The school population draws from a wide range of minority ethnic backgrounds and the majority of the students speak English as a second language.

4.6.2 Data generation process

Data collection is the first stage of the research process. In this section, I will explain the data generation process, which occurred over three phases. The first phase was meeting the staff and students and observing the classes; the second phase was selecting potential participants; the third phase was distributing the cameras and conducting the interviews. See Appendix 3 for the timeline of the data generation process.

**Data generation phases**

- **Phase 1**
  - observation

- **Phase 2**
  - Questionnaire
  - 22 students were selected

- **Phase 3**
  - 18 cameras distributed
  - 16 cameras returned
  - 16 interviews completed
Phase 1

Meeting the staff and students and observing the classrooms

The researcher obtained approval from the school’s administration to conduct the research in late December 2016, following a wait of about eight months. My supervisor and I visited the school to meet one of the science teachers, who was known to him professionally assisted us in the process of accessing the school. She was very excited and supportive throughout the project. The purpose of the meeting was to explain the project in detail. I made a short introductory presentation, which included the research questions, data generation stages and the timeline.

I started going to the school in mid-January 2017; on the first day, I met all of the staff from the Science Department during their weekly morning meeting. I introduced myself then did a short presentation about my educational background and the aims of the study and its timeline. I also discussed how the results from the research would benefit science teachers and future students and how the target was students in Years 7, 8, 9 and 10.

The staff was welcoming and excited about the potential results. Their only concern was the timeline. They wanted me to finish my research as fast as possible. They were surprised that I required a couple of weeks for observation. The reason for their concern was that they were too busy, as were the students. Due to the pressures of exams, unfortunately, the head of the science department excluded Year 10 students from participating, as they had an especially busy schedule. Consequently, I narrowed my options to the Year 7, 8 and 9 students.

On the first day of observation, I attended different science classes with different teachers, in order to explore and get familiar with the school. I came from a completely different educational background, so there was a lot to learn and observe. I therefore decided to attend any available class, which ended up being a Year 10 class. I knew they were excluded from my study, but my aim was to merely observe the class’ atmosphere, the relationship between the teacher and the students and the ‘vibes’ in the room during science lessons.

In the Year 10 class, the students were worried about an upcoming test. Their teacher told me that the government had recently introduced a new test and which they would be the first to take. The teacher also talked about the changes that have been made to the curriculum, as she believes that ‘the girls are very smart, and they can handle it, but they don’t think outside the box’.
I then attended a Year 11 class, which was a revision lesson. The teacher and students were, therefore, moving around throughout the class. I talked to one student and asked her ‘what do you want to study in future?’ She said ‘biology, because biology is more related to life. Then physics, and the last subject is chemistry’. She told me that she believes theory lessons in science are boring.

Later, I attended a Year 7 class, which was one of my targeted classes. The lesson was about electricity. I sat in at the end of the class and had an interesting chat with a group of three students. I asked the same question: ‘what do you want to study in future?’, but this time it was aimed at the students as a group. I asked them all ‘are you going to study science in [the] future?’. The answers I received were the following:

Girl 1: ‘Science is too complex, I liked physics. And math is too hard’.

Girl 2: ‘I don’t want to be a teacher. I don’t like kids’.

Girls 3: ‘I liked physics and chemistry and [the] animals part only in biology’.

I then asked ‘do you think what we [are] studying in science class [is] related to everyday life?’.

Girl 1: ‘No, because they are not going to ask you about science when you are applying for a job’.

Girl 2: ‘No, but practical science is fun’.

Girl 3: ‘Yes, I think it’s important to study about electricity’.

Girls 1 and 2: ‘No, it is not. All you must do [is] call someone to come and fix whatever you got, [there’s] no need to study it’. I did not comment on their opinion, but I think their responses were very interesting.

The last class that day was a Year 9 class with low attainment students and students with disabilities. The lesson took place in the lab, as they were doing an experiment. One of the students came to me and asked me what I was doing and what I was studying. I told her that I am a Doctor of Philosophy (PhD) student. They didn’t know what a PhD was, so I tried to explain it by saying that I was doing a doctoral degree at the University of Manchester. They all thought that meant that I am going to be a general practitioner (physician) or work in a hospital.
The first week at the school went smoothly. It involved a mixture of confusion and excitement. At that time, I discovered things I did not know before about the short-cut terminology used for things like exams, systems and programs. I wrote down any words that I did not understand in my fieldnotes and looked them up later. Again, the teachers and the staff were very friendly, but I did not want to impose. I tried to limit the questions to the ones about my research and asked my supervisor and browsed the internet for any necessary clarifications.

I joined, on average, about two to three lessons a day for a week. I did not take any notes; one of the teachers came up to me and asked me about the notes, so I decided to leave the note-taking for after class and used the class time to interact with the students, see appendix 11 for an example of my field notes. As I mentioned before, the teachers were very concerned about the timeframe of the study. As a result, they did not allow me to observe any more classes. I chose the classes that I planned to work with. I ended up with six classes: two from Year 7 high/low attainment levels, two from Year 8 high/low attainment levels and two from Year 9 middle/low attainment levels.

Unfortunately, one of the Year 9 teachers did not seem to welcome the idea of having someone in her classroom. She was always questioning me about what I was doing, what I was writing and what I would be looking for in my research. She was kind, but she tried to interfere with and dictate my research process. She also did not reply to my emails about the class’ schedule, which was necessary because I required 30 minutes to introduce myself and my research to the students. I contacted the teachers directly to arrange that 30 minute discussion following their lessons and I received five responses. The aforementioned sixth teacher, however, did not reply to my emails and began to avoid me in the school corridors, so I ended up excluding her from the study.

**Meeting the students**

After attending the science classes for less than two weeks, I decided to ask for 30 minutes for a short presentation to introduce myself to the students and distribute the surveys. Some of science teachers introduced me to the class when I attended for the first time and introduced me as a researcher without many more detail. Others did not introduce me; I simply entered their classes quietly and sat at the back, observing.

I gave each class a 10-minute presentation using PowerPoint. The presentation covered my basic personal information, my background, my educational status and what I was doing at their school. I explained what a PhD is and how they can (the students) help me by filling in
the questionnaires. The teachers were very helpful; they gave me plenty of time to do my presentation and helped me to answer the students’ questions about myself and my research and also about the questionnaire. The questionnaire did not require much time; it could be done in a maximum of 15 minutes. Almost all of the students finished in less than 10 minutes. The details about the survey will be discussed in the following section during the discussion of the selection of potential participants.

An interesting thing kept happening each time I finished my presentation: the girls shared that they did not know what a master’s degrees or PhDs were or how one gets them. They thought the title ‘doctor’ was just for people who had gone to medical school, worked in a hospital or wore a white laboratory coat. Following each of the presentations, the teachers explained to the students how to get to a doctoral program through the United Kingdom’s education system. The students’ lack of awareness about PhDs was shocking for the teachers, and for myself as well, especially when Year 9 students asked what a doctoral degree that does not require you to work in a hospital was. I believe that, at that age, students should at least have an idea about their future path. The school offers advice on this matter, so I do not know why the students do not benefit from it. Two girls came up to me and asked about the university’s fees and I referred them to their teacher. Others asked me how to specialise ‘in moving body’; this was their exact terminology, and I think they meant physiotherapy; they also asked how to learn baking. The students’ confusion in terms of both education and paths within science is something I felt the need to mention here, because if the students are not aware of their future path, in my opinion, they are not get excited and plan to achieve their future goal properly. The lack of awareness of the future path will make young people believes people who are promoting the idea that science is hard, and the tuition fee is high. By raising awareness and options about the future path, we will be able to help and clear the vouge vision.

**Phase 2**

**Selecting potential participants**

Phase Two was about selecting potential participants; the survey was not the main measurement tool. It was merely a supporting document to understand the potential participants’ thoughts about science. The research aims to comprehend the perspectives of students and their science learning experiences beyond the classroom. To achieve this, I used the ‘attitudes towards science measures’ questionnaire, which was initially designed for the Institute of Physics in the UK and which explores the benefits of a campaign called ‘Lab in a
Lorry’. This mobile laboratory travelled to various schools to motivate young children (aged 11–14 years) about science by means of relevant science demonstrations. As such, this questionnaire proved useful for this study in terms of establishing the views of students prior to their taking photographs in Phase Three.

The following aspects of students’ attitudes towards science were deemed especially important: learning science in school, self-concept in science, practical work in science, science outside of school, future participation in science and the importance of science. The questionnaire consisted of 17 items separated into seven sections. The categories of the students’ attitudes in the questionnaire followed the Likert scale, from strongly disagree (coded ‘1’) to strongly agree (coded ‘5’). See Appendix 4 for the questionnaire. The questionnaire was a reasonably reliable instrument, as measured by Kind et al. (2007); for all items, it was 0.91. In addition, the instrument has α- coefficients of between 0.64 and 0.83. Thus, it can be assumed that the instrument demonstrates a high degree of reliability and consistency (Osborne et al., 2003). This has also been investigated by a diverse range of authors, including (Adesoji, 2008, Anwar and Bhutta, 2014, Francis and Greer, 1999, Kind et al., 2007).

I received 101 responses out of a possible 107 in five classes. I entered the data manually into an Excel sheet. Appendix 5 showing the questionnaire data analysis. The rest of the data came from the school, and for confidentiality reasons, it took almost three weeks to obtain school’s data. The data from the school covered the students’ ages, ethnicities, attainment levels, spoken languages at home and the date that they joined the school. In order to choose participants for the study, I tried to look at the data from different angles. I was interested in people who were agreed and strongly agreed that science is boring. The response to this question was shocking. As this question received a high percentage of agreed and disagreed. Despite the attainment level, the majority was between agreed and strongly agreed that science is boring. The data from the school covered the students’ ages, ethnicities, attainment levels, spoken languages at home and the date that they joined the school. In order to choose participants for the study. In selecting my sample from the participants who had responded to the questionnaire, I aimed to represent the diversity of the cohort in terms of these various criteria.

Age: I selected participants from each of three year groups: Years 7, 8 and 9.
Ethnicity: Participants were chosen from each of the main ethnic groups represented in the cohort (eg. White heritage, Bangladeshi heritage, Middle Eastern heritage, African heritage, etc).

Attainment level: I used teachers’ assessments in Science to represent lower, middle and highly attaining students.

Languages spoken at home: I represented the range of different language contexts, including participants who spoke English at home, others who spoke more than one language including English, others who spoke only languages other than English at home.

Date of joining the school: I selected participants from a range of different conditions, for example some students who had arrived in the country within the last year, others new to the school, others who had joined the school from year 7. In addition, I was interested in people who were agreed and strongly agreed that science is boring. See Appendix 12 for the questionnaire data analysis.

![Figure 3. Question six results from the questionnaire](image)

I nominated 22 potential participants and then I consulted the teachers informally about my choices and the teachers were unanimously agreed with them. I met with the potential participants at the end of a science lesson in order to let them know that they had been chosen and gave them their consent forms. See Appendix 9 for full participants profile.
4.7. Ethical considerations

The ethical concerns were addressed in the following ways:

1. Informed consent was obtained from participants and their parents/guardians. Appendix 6 and 7.
2. Individual participants retained ownership of their photos. Appendix 8.
3. Permission was obtained from participants and parents/guardians to use the photographs that they generated in any presentation of the research results. Appendix 8.
4. Consent was granted based on any identifying features of the people in the photos being obscured. Appendix 6.
5. The researcher did not provide the participants with any incentives or suggestive instructions regarding what the photographs might showcase.

Two girls refused to participate, and they did not return their forms. I asked for their reasons and they both stated that they were simply not interested. As a result, I did not have time to replace those two participants. Luckily, for my supervisors and myself, twenty participants were sufficient. The participants took almost a month to return the consent forms. After the consent forms were returned, it was time to distribute the cameras to participants. I used one of the cameras to give the participants some instructions on how to take a photo and I let them practice using the camera with the photo statement guide. I verbally reminded the participants that they were free to change their mind at any stage without needing to explain their decision and that this task was voluntary, uncredited and was not a part of their school’s coursework; they agreed and stated their understanding.

There were several points at which my process of data generation became something of an ethical challenge for me.

1. A [participant] talked to me about an example of things happening in life, which could include being bullied. In this case, the participant was not talking directly about herself – she was giving an example of how in life there is a beginning and an end, and within that life many things could happen; someone could be bullied, or not happy.
I was faced with the question of how to respond to this as an educator and an adult visitor to the school, with therefore some responsibility for safeguarding. I had the feeling that it was possible that she was talking about herself, but that this was not a serious situation. I knew that she had good relationships with the pupils in her class, and with her science teacher. So I decided to remind her that she could always talk with someone if she was worried about any situation, but I did not feel that in this case it was appropriate for me to raise this directly with the teacher myself. I felt that if she wanted to talk further to me, she could.

2. At times I observed and listened to teachers’ expressing their frustrations and constraints on them, arising from the stressful situation which many teachers work under at times.

I decided not to include such observations in my thesis. I did not feel that this was relevant to the research question, and it would not have been fair to introduce these challenging episodes into my account, there is no doubt that professional reputation is extremely important and the recognition of the difficult job which is often misrepresented. I consciously decided that my research account would not add to this literature of representing the profession in a bad light.

4.8. Validation and Trustworthiness

To make sure that this qualitative research study assisted in enabling a greater understanding of the perspectives of young people towards science, I employed the validation and trustworthiness approaches. It is advised that a qualitative researcher employs at least two validation approaches (Creswell, 2014). The approaches that I found to be the most suitable for this research were member checking and triangulation. Member checking is described as a quality control procedure which the researcher pursues to enhance the accuracy, credibility and validity of what has been documented or what has been interpreted in the outcomes (Harper & Cole, 2012). This procedure fits well within this research because it was essential to me that the participants considered the transcripts and the outcomes to be authentic. Member checking took place throughout the interviews by asking questions such as ‘Am I understanding this accurately?’ or ‘Did I capture what you said correctly?’ I also maintained the member checking process after the testimonials had been transcribed all through follow up communication sent to the participants via email. Member checking also took place in the photo-elicitation interviews and was a steady component of the plan, as the participants confirmed and explained their pictures. Triangulation is identified as the utilisation of several data sources in an
investigation to generate understanding (Creswell, 2013). In this case, visual, verbal and reflexive data sources assisted in clarifying the coherence in the study. The primary testimonials set the stage and were intended to answer the research questions. The observation and the transcripts of the photo-elicitation interviews were effective in tackling all of the research questions. It was essential to me to analyse at what point these data sources come together, as I realised that it guided to a powerful and meaningful set of insights. I also implemented another method of triangulation, that is, exploring and looking at the data sources at several stages in time: i.e. before the interviews, at the testimonial stage, during the photo-elicitation interview process and at the final sitting (Patton, 1999). The major outcome of triangulation is not exclusively consistency, in fact, there may be moments in which the data is not consistent, but the goal is to be able to recognise what and why there are variations (Patton, 1999 p. 1195). Finally, to help ensure this investigation's trustworthiness, I looked intently at my role as the researcher. While the researcher is seen as an instrument in qualitative inquiry (Patton, 1999), my teaching, my personal experiences, my perspectives, my relationship to the participants and my relationship to the institution are all influences that were mentioned to my participants and in my write-up of the results. It may perhaps be said that I am both advantaged and disadvantaged by my embeddedness in the university as a science education researcher, as a person who has been a science teacher for years and, also, in my own experience as non-English native speaker. It is beneficial for constructing understanding, simplifying questions and, also, for having compassion for the experiences of my participants. However, I am mindful that these perspectives can also operate as blind spots, since I am personally and professionally devoted to improving students’ understanding of science and strengthening the relationship between young people and science. As Patton (1999, p.1198) states, ‘The principle is to report any personal and professional information that may have affected data collection, analysis and interpretation either negatively or positively in the minds of users of the findings’. I was clear with the participants before data generation and during the research. I additionally employed the routine of reflexivity by maintaining an electronic research journal in which I recorded any modifications to the data generation or data analysis procedures that I made along the way.

Phase 3

Distribution of the cameras
Eighteen participants were each given a disposable camera accompanied by a photo statement guide (see appendix 10 and the start of Chapter 5). They were asked to take photographs outside of the school. Each camera was labelled with a capital letter indicating the students’ initials and their year of study. I asked the participants to start taking photos as soon as possible. I also told them that they could return the cameras to any staff member in the science department. I made the mistake, however, of not setting a deadline for the students to return the cameras.

Several issues emerged during Phase Three. First, no deadline was given for the participants to return the cameras. I was aware of the importance of allowing them adequate time, as four students who refused to join the study did so because they said that they did not have enough time, as they needed to prepare for an upcoming test. So, I thought I would leave the timeframe for returning the cameras open in an attempt to minimise pressure on the participants, especially since the pilot study showed that time consumed by the photography itself was not more than one week. Unfortunately, in this case, it did take longer than a week; the whole process of distributing and returning the cameras took about six to seven weeks, plus an additional week for developing the photos, so the total was eight weeks. By that time, we were close to Easter Break, 2017.

The second issue was related to our decision to do the photo elicitation interviews in pairs in order to reduce the power imbalance. The problem with this was that often, one of the pair would return the camera but the other kept forgetting. I asked the teachers for help, and they called the students after school hours to remind them to put the camera in their school bags. One of the participants lost a camera; I replaced it with a new one but she keeps forgetting the second camera as well and never ended up returning it. As I mentioned above, the reason for putting the participants in pairs was to reduce the power imbalance, but I also wanted the participants to be able to speak freely. My participants were not friends and did not sit next to each other in the classroom, but they were familiar with each other. This was helpful, as each pair were from the same class and because they were doing the interview together, they were able to remind each other of the interview time and ensure that they were both on site at the science and technology building. The school is huge and has four different buildings and we only had a 45-minute time slot and the participants also needed time to have their lunch.

The interviews were arranged immediately after the first pair’s photographs were ready. For each interview, I would go to the classroom before the lunch break began, inform the participants of the specific room that I was waiting for them in and tell them that they could
bring their lunch and eat it there. The interviews were done during the lunch break in a science classroom that was offered up by one of the science teachers. The participants and I sat around the table, facing each other. I let them know that I had a voice recorder and that I would be recording our interview for research purposes. I also reminded them that they were free to stop me or refuse to answer and that they could leave the interview if they needed to.

**Interview status**

The main aim of this research was to explore and interpret young people’s views about science and its relationship to the real world through the use of visual images. Photographs alone may provide an important insight based on the types of pictures that were taken, but without deep comments and conversation, we would have not had an understanding of the intentions, motivations and conventions influencing their photo-taking. The research was designed to provide an opportunity to examine the findings and to identify both the limitations and the role of photo elicitation as a method. During the interviews, a relaxed approach was taken. Some of the participants went through the photos one by one, followed the photo statement order and explained where and why the photos were taken. Others took their time deciding on the order and spread the photos out on the table so they could have a full view of them before beginning to talk about each one individually. They would then start with the photo they preferred. I always started the interview by asking ‘which photo would you like to talk about or start with?’.

During the interviews, I labelled each photo with the number of the statement, so it could be identified during the data analysis. Each participant was asked to talk about why they took each photograph and the interviews were otherwise unstructured. I used further questions and probes relevant to each interview in order to elicit participants’ perceptions of science and to understand their approach to photo-taking. At the end of each interview, the participants were asked if they wanted to keep the printed set of photographs. None of the participants wanted to keep their photographs. My own feelings and thoughts about the interviews were also recorded, including how each participant appeared in terms of body language and disposition. All interviews were recorded using a digital voice recorder and transcribed verbatim.

**4.9. Pen Portrait**

The Pen Portrait methodology in research, as described by Stake (1995), is an approach used to investigate, in-depth, the programs, experiences, activities or practices for one or more, which could be individual people, institutions or settings. Time and activities are the ‘cases’,
and by employing a range of data generation techniques over a sustained period of time, researchers are able to accumulate detailed information. In this case, the purpose of the study was to understand young people’s perspectives about science as deeply as possible. The data in this study was generated through in-depth photo elicitation interviews. Interviews were conducted and audio-taped, the tapes were transcribed into word documents, district documents were reviewed, and the data was coded for emergent themes. Another element of the Pen Portrait is the unit of analysis, classified as the area of focus of the research (Yin, 2012, Merriam, 1998). For this study, the unit of analysis was the individual participants in the study, of whom there were five.

According to (Yin, 2012), there are five components of a successful Pen Portrait research strategy: (1) research questions, (2) purpose of study, (3) unit analysis, (4) logic that links data to propositions and (5) criteria for understanding the findings. For the first component, the most suitable questions for this type of qualitative Pen Portrait research were ‘show me’ and ‘why’ form of questions.

The second component of Pen Portrait research strategy is to clearly identify the study purpose. This component is most commonly recognised as the ‘purpose statement’. My purpose in this Pen Portrait was to understand the students’ individual experiences with science and to explore how young people connect to and disconnect from science.

The third component of the Pen Portrait research strategy is the unit of analysis. The unit of analysis, as Yin (2012) described, is the focus area that a Pen Portrait analyses. An appropriate unit of analysis is formed when primary research is precisely specified. The unit of analysis is clearly bound to the research questions established by the researcher. This study’s unit of analysis is a school in the northwest of England with a student body of mixed ethnicity and background.

The fourth component of the Pen Portrait research strategy is that there is a logical link between the data and the theoretical proposals. In this Pen Portrait, the data from the interrelated cases give a rich perspective on the cultural models of five individuals, and this directly addresses the research questions. The themes that emerged in this study, therefore, provided answers to the research questions presented in Chapter One.

The fifth component of the Pen Portrait strategy is the criteria for interpreting outcomes. Generally, the Pen Portrait researcher codes the data before developing themes (Yin, 2012).
Following the theme development stage, I carefully extracted meaning from the findings to define suggestions for practice and future research.

4.10. Data Analysis

Qualitative research studies require a constant interaction between data generation and data analysis (Strauss and Corbin, 1994, Charmaz and Belgrave, 2012). For this reason, I began analysing the first interview in order to start finding patterns and to facilitate the data generation that would follow (Charmaz and Belgrave, 2012). In this study, the data was first analysed using thematic analysis. When I analysed the data and themes started to appear, I noticed how each individual is unique and how the flow of the narrative data is very interesting. I also noticed how some of the young people dealt with each statement as requested and moved to the next statement to generate a new idea and understanding. Not all of the participants provided photos for each statement; many of them took photographs for the first three photo statements and then gave up. Applying the Pen Portrait techniques was done to explore each person’s views about science and to understand the flow of the perspectives and the connections that the students made. According Sandelowski (1995) qualitative analysis is a kind of creative technique. He also claims that there is no standard process to qualitative research, since data analysis is a method of making sense of things. It is an intellectual method, not an automatic one (Jacob and Furgerson, 2012, Denzin and Lincoln, 2008). This is similar to what (Stake, 1995) said: that qualitative studies benefit from conventional ways of making sense of things. Stake reminds all qualitative researchers that ‘there is no particular moment when data analysis begins’. Stake defined the ‘analysis’ as taking something apart. By applying Stake’s definition of analysis to this study, analysis is, therefore, not only about understanding the ways young people make sense of connecting science to the real world but, moreover, about recognising and identifying the emerging patterns from that process. The qualitative data analysis from this study tells the story of how young people make sense of the relationship between science and the real world.

This study followed the data analysis and coding techniques recommended by (Creswell, 2009); (Epstein et al., 2006). In particular, Epstein et al. (2006) recommended open coding, a method in which ‘you work intensively with your data, line by line, identifying themes and categories that seem of interest’ (p. 158). Furthermore, Creswell (2009) recommended the old-fashioned style of social sciences that permits codes to emerge through data analysis (p. 187). Once the data from this study was examined carefully using the open coding method, I evaluated the codes for emerging themes.
For this study, I followed Creswell’s (2009) six-step data analysis process. He described these steps as ‘an interactive practice’ of analysis.

Step 1: Organise and prepare the data for analysis (p. 185). During this step, I reviewed audiotapes from interviews and transcribed them into Word documents.

Step 2: Read through the data (p. 185). I reflected on the whole sense of the words to obtain a common idea of the data and concepts that the participants expressed. This step also lines up with Esterberg’s instruction to ‘get to know your data’.

Step 3: Begin a detailed analysis of the coding process (p. 186). I pursued Creswell’s technique of forming the data into segments by using the content data and segmenting sentences into categories. Subsequently, I labelled those groupings with terms based on the authentic language of the participants.

Step 4: ‘Use the coding process to generate a description of the setting or people as well as categories for these for analysis’ (p. 189). I used this process to generate codes for the descriptions, which then led to generalising a small number of categories or themes. I then analysed the themes that emerged and gathered the various cases into a general description for this limited case.

Step 5: ‘Advance how the explanation of the themes will be characterised in the qualitative narrative’ (p. 189). For this step, I transformed the themes that appeared into narrative paragraphs, so that the results became apparent from the participants’ answers.

Step 6: ‘Interpret the meaning of the data’ (p. 189). During my own analysis process, my involvement as a science educator informed my understanding of the participants’ narratives. Also, to express the participants’ views of their experiences correctly, I concentrated explicitly on what they were saying, their assumptions and their plans for the future. The emerging themes came directly from my understanding of what Richard and Lahman (2015) called ‘the healthy tension’ between the participants’ own meaning-making methods and my own biases.

4.10.1. The process of analysing photo elicitation interviews by NVivo software

Conducting the interviews, which were supported by the participants’ photographs, were the first step of data analysis. As Rabiee (2004) said, data analysis begins during the first interview. All interviews were transcribed by me. They were then imported into NVivo 12, which is a
software used for qualitative and mixed-methods research. This program is used to help analyse and interpret textual data. As the data generation phase went smoothly, the only obstacle was that it was unexpectedly time-consuming. Because I was extremely anxious about time, I thought it would be easier and faster to analyse my data by using pen, paper, sticky notes and a wall map.

At the beginning, I analysed my data manually using a wall map see appendix 14. This method was time-consuming and hard to organise when the results began to appear. As the map began to grow, I worried that I was missing vital connections in the results, so I start to look for another way to save both my data and my time. I decided to try a data analysis software, NVivo. A new challenge arose from this method, as I did not have any previous experience using this software, so after downloading the software from the university’s IT website, I started teaching myself how to use it, relying mostly on YouTube tutorials and the NVivo Toolkit book.

The online tutorial and the guidebook were not enough to answer all my questions; I needed expert help. I found a two-days course for beginners at the University of Surrey, so I signed up and travelled to Guildford in February 2018. It was a very helpful course and I started to import my data to my Mac laptop and began working on it on the second day of the workshop. After working with and getting used to software, I realised that I needed some features that were not available in the Mac version, so I decided to work on a PC. Unfortunately, during the process of uploading the data, both versions – the Mac and PC – crashed, and I lost all my data. It is not normal to lose your data during the transformation process, but in my case, my data included photos which made ‘NVivo angry’ and the program lost it all, according to NVivo’s online help service. It was hard to start over, but the wall map, the writing I was constantly reviewing with my supervisor, as well as my research diary, all got me through.

4.10.2. Data Coding

The nature of this study was one of exploration. I started with an open-ended thematic code structure (Flick, 2006). To develop this approach, I was deeply involved in the data and searched for dominant themes and concepts, or ‘repeatable regularities’ as (Miles and Huberman, 1994) suggested. Because of the researcher’s role in the process of analysis, and based on what I was reading about the science education field, themes did not simply ‘emerge’. Instead, as Richards and Morse (2012) wrote ‘the researcher “emerges” ideas, categories, concepts, themes, hunches and ways of relating them’. Consequently, both a priori and a
posteriori categories were created (Wellington and Szczerbinski, 2007). All data were anonymised, transcribed and uploaded onto NVivo 12. Each participant’s data was kept in a separate folder showing their anonymised name and year of study.

Most research studies analyse visual data by using coding, sorting or content analysis to be able to analyse a large number of photographs in a short period of time. I coded the photographs based on the task that has been given to the participants to follow. After all of the interviews were completed, I started entering the data into the NVivo software. NVivo allows you to upload your text along with photos. The coding process in NVivo highlights the items in each photo and includes ‘nodes’ to explain which theme is appearing. All of the data was coded, including the interview transcripts and field notes.

Coding of the photographs and the interview transcript data were developed separately. Nodes for the photographs were kept as ‘free nodes’. Each node stood independently from the rest of the list. As this was my first time trying to analyse visual data, I completed the entire coding process and then grouped the nodes together. It was the most cautious approach that I have ever taken. I organised the textual data in ‘tree nodes’ earlier, before completing the coding to help me simplify the coding process. I then grouped the tree nodes together with the free nodes, which thematically groups similar nodes. For example, nodes such as ‘we need water to live’, ‘we used the internet every day and the electricity, this part of your life’ and ‘they gave us oxygen’ were grouped in the tree node of ‘human needs’ and nodes such as ‘how the animals live’, ‘how the babies inside developed bones’ and ‘how those plants grow older’ were grouped into the tree nodes ‘curiosity about changes’. Free nodes were moved between tree nodes and the tree nodes were frequently revised until the coding frame was done. The next step was analysing the data by distinguishing which data related to which statement.

4.10.3. Interpreting the data

When all the coding had been completed, I reflected on the thematic visual analysis that had been achieved with the photographs and distinguished any ways in which this method was engaged in the interpretation of visual data. A thematic visual framework of the study was constructed, producing a ‘thin description’ of the science education setting (Geertz, 1973). Throughout the interpretive process, I aimed to reflect on the data in terms of the discourses they constructed or drew upon. The principles of the theoretical perspective of discourse analysis techniques have guided my theoretical viewpoint. For the interview data, themes were
divided in relation to each statement; we had five statements. We were looking for connections, so main themes were developed: science in school and science outside of school in everyday life. The challenge was that the participants' examples of science outside of school came from their science lessons.

4.11. Summary

A qualitative research approach, the photo elicitation interview technique, was used to collect data about how young people explore the connection and disconnection between science and the real world. Seventeen out of 18 participants aged 13 to 15 were given disposable cameras and asked to generate a series of photographs which described ‘how science is connected and disconnected to their world’. Participants then took part in an interview with the researcher to talk about how their photos represented their thoughts about science.

The chapter also explained the data generation stages and how they were analysed. The data was analysed thematically by using NVivo software and the Pen Portraits technique. The results of the study are shown in the following two chapters. This data provides support for improving and a better understanding of the current absence of knowledge of students’ experiences in terms of exploring and understanding the field of science education.
CHAPTER 5:
The Results
5.1. Part one: Pen Portraits

5.1.1. Pen portrait 1: Ayah Y9

Ayah’s profile

Ayah is fifteen years old. She is in Year Nine and placed with the middle attainment level group in science classes. I did not choose Ayah from the survey results; she came to my desk to tell me that she was interested and very keen to join the study. I could not reject her since I’d already had three girls from Y9 refuse to join the study.

Researcher thoughts/observations:
In the classroom, Ayah sat in the front and was fully engaged with the teacher; she was always busy writing notes and answering the teacher’s questions during the science lesson. Outside the classroom, Ayah is friendly and funny. When we met for the interview, she was relaxed and asked me many questions about myself; she hesitated before we started the PEI and kept telling me that what she wanted to say was hard to explain. She asked me to pick the first photo even though I let the participants choose their starting photo based on their own preference. Ayah was so excited to talk about what inspired her to study science and the principles by which the real world mean, however she often seemed confused and had many things to say about science and science lessons.

Survey result:
Ayah’s survey results showed that she was very positive about science, only she didn’t want to be a science teacher in future. Science, however, is only her third favourite subject in school after literature and art.

Science teacher perspective:

Matt: She’s got a lovely enquiring mind. She will do well. She is possibly the antithesis of Mila in the fact that she will strive and strive and strive to do better and she will overachieve in science because she’s got a desire to do well [and] therefore she will try and do as well as possible. It is a pleasure to teach her. In
From Ayah’s science teacher’s point of view, her attitude toward science shows a keen interest and desire to work hard and do better. Matt mentioned that Ayah has an investigative mind, which we can see from Ayah’s response to the photo elicitation interview in the following section.

**The photo elicitation interview:**

Ayah came to the interview room on time along with Layla. Ayah volunteered to be the first to interviewed. She chose statement No. 2 to begin with: **showing how you see the real world with science in it.**

Ayah used a picture of a tree to show how she sees the real world and science as being connected. From Ayah’s viewpoint, the plants represents the real world and the science is studying photosynthesis. She says, ‘in science we studied’ and then ‘with plants and how plants’ then ‘inspired to learn what inside’. Notably, Ayah does not call the tree ‘nature’. She thinks of photosynthesis as science because she studied this information in science class. Ayah’s answer was quick and short. I wondered whether she simply viewed these things as common sense – as we will see in the next chapter, this is a frequently-held position.
Ayah thinks that having trees around us encourages us and inspires us to know more about what is going on inside the tree, which, as a result, allows us exploring the process is science. It seemed to me that Ayah views the relationship between science and the real world in the form of exploring our environment. Ayah is very smart and was ready to talk more, but I tried to not ask for more details in order to keep the participants relaxed and stay away from creating the atmosphere of an exam.

Next, Ayah chose to talk about prompt No. 5: **take a photo of something that inspired you to do science.**

![Figure 5. the ground](image)

*Ayah:* The ground. It has inspired me because [it] is like something [that] is really small. We look to the sun, we look to the plants, but we don’t really notice [what] the ground is really made of, so I think [if] we know [what] this stuff made of, I think that’s really fascinating and that’s why I want [to learn] science and how this was made and when [it] was made.

*Me:* Do you think the thing that made the ground is related to science?

*Ayah:* Yeah.

*Me:* Do you think you [are] going to do in [the] future anything related to science?

*Ayah:* I wanted to do something... I don’t know what is called, it has something to do with geography and science, people who go on mountains.

*Me:* What is science for you?

*For me,* I think like explained the world to me. *For example,* religion and science [are] completely different things, but even though, like, I think some [religious] people, they don’t believe in science, but I think [they] go hand in hand, beside in wonder. *If* you are a religious person, you [are] going to see the world in [a] scientific way and the logic behind everything is science.

As I mentioned before, Ayah was so excited to talk about this statement in particular. Ayah took a photo of the ground as an example of what inspired her to study science. She was curious to know what the ground is made of and when the ground was made and what the consistency of the ground is as well. She seemed to have many questions.
She assumed that we ignore or, in other words, do not pay much attention to the ground because it is something we see as insignificant. She gave an example of the trees and the sun as something we look at, and we do not wonder where they come from, or what they are made of, because we know where the sun and the trees come from. Ayah did not say what the sun and the plants are made of. However, she claimed that no one really notices the ground or wonders what the ground is made of, so Ayah believes that by studying science, she will be able to know where things come from or what they are made of.

Ayah’s response made me want to know more, and she was ready to tell me more about her views. The excitement she felt about answering this statement made me want to know if she plans to study science in the future. Ayah has already expressed that she does not want to be a science teacher according to her survey results, so I changed the question to be: are you going to pursue any science-related studies in the future? She wants to be a geologist, but she has no idea what the field of study is called. The ground is the area that Ayah found it interesting and wants to study it in the future, but she does not know any information about it, even though she is in Year 9. The way Ayah sees science is positive, which made me want to know what science means to her. Ayah views science as something that can explain the world. From her perspective, science is it the process of enquiry. Ayah then moved on to discuss a sensitive issue in the Muslim world: different explanations of the world, based in religion and in science. Ayah is a hijab-wearing Muslim and talked about how Muslim people may understand science, and how some religious people do not believe in science. I felt that she may have been thinking about herself or her family.

Ayah’s words stimulated me to reflect on my own experience as a Muslim, whereby to question anything relating to creation is forbidden. As a science teacher, I would say there is potentially a red line and limitation in connecting science to the real world, especially when working with young people from religious communities with a very strict interpretation of Islam. This is something that I am aware of from my previous experience.
The next statement we discussed is No. 4: showing a connection between science and the real world

Ayah: I tried to take photo of the metal thing, because right now in science we are learning what [are] metals and [what are] not metals, so that’s why I took a picture of this, to show the metal. In science, we only learned about the properties and products of the metal, but we don't actually see it in the real life.

Me: What do you mean by ‘seen it the real life’?
Ayah: you know for example in chemistry we learned about different properties of metals, we rarely got to do, like, experiments to actually see a metal coming from somethings else. We only learn about [it] but we don't see it.

Me: Do you think we need to see it?
Ayah & Layla: Yeah

Ayah took a picture of the lift access key because it is made from metal [and served] as an example of how the real world is connected with science. In this photo, the metal [symbolises] the real world and science at the same time. Ayah brought this in as an example of what she has been studying in science class, and I felt that it could be a sign that she thinks very deeply about what she is studying (or perhaps this is the only example of science she can think of from her science lessons).

To explore further and to make sure I was not making false assumptions about what Ayah was saying, I asked for more details; she came up with another example from her chemistry lessons. Ayah complained about the lack of hands-on experiments in the classroom and suggested this may be the reason she finds it hard to see the connection between science and the real world. She claims that experimenting in science lessons would help to prove what they are studying and help to connect it to science. Interestingly, Layla was sitting beside us, and she commented for the first time: ‘yes, we need to do experiments’, so Layla agreed that experiments would help.
For each photo she brought in, Ayah references what they had been learning in science classes. Science lessons are the starting point for the conversation. From Ayah’s point of view, seeing the scientific properties in action would help her to understand and connect science to the real world.

I actually have the same concern; I do not know why we do not study where metals and their properties come from or how they are used (eg. with the lift equipment). Ayah expressed a belief that metal is connected to science because she studies it in science classes, although metals in the real world are never present in those classes. She knows that metal comes from the real world, but this connection is never made within her science lessons.

Ayah’s response to the first statement, no. 1: showing how you see the real world.

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| **Ayah:** Money, because I don't personally see the world [as] all about money, but most people like... I remember once in the class a teacher was asking us what job you want to do, and everyone was like ‘the one with most money salary’. I was like... there [are] so many other things more important than money, but still everyone wants money more than any things else.
**Me:** So, if the money not the real world for you, what is the real world, then, for you?
**Ayah:** [The] people that you meet around us; family, friends and other relationship.
**Me:** So, you said before [that] the real world is flowers and plants, like nature; [are] they still in the real world, too?
**Ayah:** Yeah. |

Ayah did not take any photo for this statement; she had already prepared for it. Ayah seemed to have already discussed the answer with other Y9 students. She started from the opinion of other people, which is that money is the real world.

Ayah sees the real world as her social life: her relationships, family and friends. I was not sure why she talked about money, because money is not how Layla saw the real world, either. Then, when I interviewed Mila from Y9, I found out that for Mila, real world is money (Mila is also a participant). That is why Ayah justifies why money is not the real world for her at the beginning. So, in this case, Ayah is using what she knows of other people’s thinking to articulate her own different and particular point of view. This is unusual, based on my interpretation of young people’s responses. As well, Ayah still believes that nature is the real world, too.
The last statement, which is **No. 3: showing how science is disconnected from the real world.**

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Ayah: *I didn't take any photos for this one, because [for] chemicals like... we have doctors and people make medicine, but [they do] not actually represent the real world. We know that people use chemicals to make stuff, but we don't personally do it, so for us [it] is nothing... like, I don’t know how to explain it. When we eat something, for example, it might [be that] there is a chemical on it, but we don't say ‘oh my god, where did this come from?’ and put the chemicals on it. So that [is] why I think [it] is disconnected from the real world, because we don’t always think that, if something comes close [to us], how [it] is going to affect you.*

Me: *So, chemicals are related to science only not to the real world?*

Ayah: *Yeah.*

Ayah did not take a photo for this statement either. Ayah claims that the connection must be visible; she thinks that if we are not able to see it, that means it is not the ‘real world’. She gave the example of doctors and pharmacists preparing a medication. Ayah said ‘to us’, so she positioned herself to speak for all young people. She thinks the lack of doing experiments at school made it hard for her to believe that such things really exist, which I agree with and which made me think about young people who do not have the chance to do any experiments at all or have any access to other media, and all they can see is in their science books. Ayah seemed to have many examples and she really thought deeply about each statement. She gave another example about food chemicals, by which I guess food additives, from ‘put the chemicals on it’; or perhaps she just means that if we do not ourselves do something with them, then we do not think about them, and they *may as well* not exist.

Summary:

Ayah comes across as a very reflective and articulate person in this case. She expressed some complex ideas about the relationship between science and everyday life, and she did this using both her own terms and also with reference to other people’s ideas, where this was helpful. For example, she notes how other people have different ideas about money, and also how some religious people hold a very different view about the possibilities of science. Ayah can be critical of the science education she is receiving, particularly in terms of how abstract and unconnected it seems to be from what she thinks of as ‘real life’. Interviewing Ayah was very interesting, as was having photos to facilitate the communication and illustrate her view of science. I think a regular or typical interview would not do. Ayah was smart, as the science
teacher told me, and she brought up some valid points about the struggles young people face in science.

5.1.2. Pen portrait 2: Ameerah Y8

Ameerah’s profile:

Ameerah is 14 years old. She is from the Middle East, and the language spoken at home is Arabic. She speaks and writes in English very well, however she seems to not have enough scientific vocabulary to explain all that she has to say about science in detail using English. Ameerah moved to the United Kingdom seven years ago. She has four siblings: two sisters and two brothers.

Researcher’s thoughts/observations:

Ameerah loves science and is extremely interested in studying science in the future. She talks a lot about her dream of becoming a dentist and how her father is a great motivator/supporter. She was thrilled to find out that we have the same background as we are both from the Middle East, and she sometimes tried to speak Arabic with me to impress her friends. This, I believe, contributed to our mutual trust and allowed me to know more about her personal life.

Ameerah as a pupil: I knew before I did the survey that I would choose Ameerah to join my research project for many reasons. Ameerah is a perfect example of an ideal student in the classroom, that any teacher would want to have. She paid full attention to her teacher and followed her instructions; she was very engaged in science class. Ameerah’s notebook is full, organised and colourful. She expressed a keen interest in science through her notebook and her attitude in science class. Ameerah was eager to help everyone who needed help with the given tasks during science lessons.

Despite her passion for science, she placed in the lowest group in science class based on ability and she knows it. I wonder if the students’ knowledge about their attainment level affects their performance and confidence. I remember her telling me ‘Miss, I am with the lower ability group’ while looking down with a sad face. Lastly, no one in Ameerah’s family is working in any science field. According to Ameerah, her mum and dad stay at home and do not work at all.
Survey result:

Based on the survey results, Ameerah has a very positive attitude towards science. She strongly agreed that studying science in school is exciting and fun and she stated that she always looks forward to science class. However, science was not Ameerah’s only favourite subject in school; she loves art as well. She does not want to become a science teacher in the future (she wants to be a dentist).

Ameerah left two of the survey questions about doing science outside of school unanswered. They were about the desire to join a science club at school and about reading science magazines; she told me that she did not understand what a science club is or what a science magazine looks like. Lastly, Ameerah strongly disagreed that science is boring.

Science teacher perspective:

The science teacher claims that Ameerah’s performance in science exams is entirely unequal to her efforts during science lessons. No matter how hard she works, she is always doubting herself and not sure about the correct answer and is likely to leave questions empty. As a result, she gets lower grades.

Ameerah’s science teacher said:

‘Ameerah is really a lovely girl. She works very hard during science lessons, you can see how passionate she is about science. Ameerah engages very well in science classes and helps me with other students. The only things [that] made me sad and [made me] wish to help [her is] that she is not doing very well in exams, even though she tries so hard. The problem with Ameerah [is that] she is a very hesitant person; she doubts everything and gets back to me for everything or leaves it empty’.

The photo elicitation interview:

Ameerah was very excited from the beginning. She arrived 10 minutes late to the interview room of the queue for lunch. I started the interview with Luna first and left Ameerah to finish her lunch. She was so excited and happy to do the interview and nervous at the same time. She looked at Luna’s photos without commenting. When she finished eating and was ready to be interviewed, I gave her the envelope containing her photos to keep her busy and to prevent her from concentrating on Luna’s last answers. She did not identify the photos and said to me ‘Miss, [these] are not mine. Are you sure they are mine?’ I was sure they were; she then found a picture of her house and began to remember everything.
We spread the photos on the table and she started to talk about each one based on the order she had placed them in. Ameerah looked at me and said 'Miss, is hard to explain'. She was talking with confidence and assurance all the time, but as I mentioned earlier, when she dived deep into the details, she appeared to get lost and started to doubt herself and to looked for a gesture of agreement from me. In terms of her body language, she was serious and maintained eye contact at all times. At the same time, Ameerah was relaxed and respectful. I had to put a stop to her talking after each question because of the time limits; otherwise, she would have kept talking and jumping from one topic to another.

I let the participant select the photo to start with. Ameerah chose No. 1: Showing how you see the real world. Ameerah chose this picture to present her understanding of the real world.

Ameerah: *I think this is the real world. Because I think the blue and green is like the Earth and the Earth is like the real world; [it] has rivers, trees and animals. That is what I think. The trees and the sky make [up] the Earth’s colours and the Earth has, like, the real world with the rivers and trees and animals and people. Yeah, this the real world.*

This picture shows the top of a tree and a clear sky. Ameerah’s focus was on the colours, blue and green. The colours represent Ameerah views about the real world. According to Ameerah, the real world means trees, rivers, the sky and animals.

She analysed the photo step by step, in terms of the way she understands it. Ameerah believes the blue and green represent the Earth’s colours and that the Earth is the real world; she then explained what the real world contains, which is trees, sky, rivers and animals.

Ameerah talked about things that are visible, like trees, rivers, animals and people. Visibility is one of the common themes the students spoke of and a shared understanding of the
relationship between science and the real world existed between the young people. We will present and discuss these themes in the next chapter.

No. 2: Showing the real world with science in it.

![Figure 8. Electricity](image)

*Ameerah*: I took this picture near my house because the electricity is science and the real world, as I said, is green and blue like the Earth, and the electricity becomes like science. For example, like when [we] use the electricity for the cars, homes and like other countries. And the green trees, they [give us] paper, [which is used] for science [and] recycle[d] for science. So, I thought that trees could be [used] for science and for the real world as well. When they [give] a paper, you recycle the paper with the right bins.

This statement shows how Ameerah developed her thinking during the interview. First, Ameerah thinks the electricity (the rail station wires in the picture) is science and the blue and green represent the real world (the trees and the sky). Then, because I was listening to Ameerah without commenting, due to what I addressed earlier about Ameerah tending to hesitate, Ameerah continued talking and she started to realise while doing so that the tree leaves could be an example of science as well, since we can recycle the leaves to produce paper.

The green tree and clear blue sky represent Ameerah’s real world from the first statement response. It shows how Ameerah believed the real world is represented by the Earth, which is blue and green. She was keen to present the real world with science in it, so this picture is a perfect presentation from her point of, because the picture has the green trees, the blue sky and the electrical wires – the Earth’s colours and examples from her science lessons.

She might have chosen electricity to represent science because that was the unit they were studying during the time of this research. Ameerah’s examples to represent science are from the science lessons it seemed to me that Ameerah’s idea of science *itself* is what she is studying.
in science classes. Electrical wires were the example she gave of science; in my opinion, she again chose something visible. Ameerah might need something visible to represent science. From the first and second statement, both the real world in general and the real world with science in it are represented by visible examples; the examples are not deep and do not show critical thinking. Ameerah talked about the trees and the electrical wires on the street. Ameerah understands science as what she is able to see with her eyes in front of her and what she already studied in science class. In my understanding, in this process, we see Ameerah starting to make sense of what science is – very much linking it back to class and holding on to what she has already studied as a reference point.

No. 3: Showing how science is disconnected from the real world.

Ameerah: Okay, I think this one is not connected to the real world because this the food label, because the food label is not really related to the earth. Food label is like... food has a label talking about fat and weight and information. That is what I think they are not together, they are different, because this one talks about food. The ‘real world’ talks about humans, rivers, animals, trees, air. But this one [is] just like food.

Me: [Does] that mean the food label is from science?
Ameerah: Yea, the food label is from science, but we disconnected them because [a] food label is different from the real world. The real world is like air, life. This one is like, only [the] food you eat.

The photo above is not clear; Ameerah was trying to take a picture of the food label to represent the disconnection between science and the real world. She thinks the food label is an example of how science is disconnected from the real world. She thinks the food label is science, perhaps because she has studied it in science class. Ameerah made a distinction between science and the real world. To her, the real world is humanity, rivers, animals, trees and air, which she calls
it ‘the Earth’, whereas food nutrition information or perhaps the concept of ‘the food you eat’ itself for Ameerah, is science.

Another possibility is that Ameerah thinks science is about information and facts. Ameerah’s response made me wonder if she thinks food labels are science because she studies them in science class, or because it is information and facts and whether science is a set of facts and information, or both. I am not sure which way of understanding is leading the other. Alternatively, maybe neither or both understandings are represented in Ameerah’s knowledge of the disconnection between science and the real world. Moreover, this again shows how, with each photo, Ameerah returns back to what she has studied in science class.

No. 4: Showing a connection between science and the real world.

![Figure 10. Sun plant](image)

**Ameerah:** Okay, the real world is nature… and as we said, [in] science, there are leaves… I don’t know how to explain this, do leaves give you paper, or just only the trees? If the leaves give you paper, so it’s recycling and [the] real world is nature, so [it] is like the Earth.

**Me:** So, this is the connection between science and the real world, so the science here is just the recycling and the real world is the flowers.

**Ameerah:** it could be about sun plant, it is like you have sun plants, like how to make the leaves green, how to like, to keep the leaves like grown. Okay so this is science, yeah. Sun plant.

Ameerah was confused about this statement; she was thinking of the same picture for both Statement One and Statement Four. I told her that it is okay if she thinks one photo would fit two statements. After a few moments, she replied ‘okay, the real world is nature’; she began to call the real world ‘nature’ for the first time, not the Earth. Ameerah thinks the ‘sun plant’ shows the connection between the real world and science. The meaning of the word ‘sun plant’
was not clear to me at the beginning, but she explained that the ‘sun plant’ is what makes leaves green and helps them to grow. I think she means photosynthesis, though she did not say that. Ameerah sees the connection between science and the real world as being the relationship between nature and the process of the leaves’ growth. Clearly, this is something she studied in science class. Ameerah was not sure about the recycling example. She was struggling to explain it to me; she does not know if paper comes from the tree trunks or the leaves. Then she decided that the ‘sun plant’ is science. I do not know where the term ‘sun plant’ comes from, however I think that it is brilliant and interesting that Ameerah has comes up with her own word to explain/deliver an idea.

No. 5: Something or somewhere showing the connection between science and the real world from your home.

![Figure 11. My neighbour’s garden](image)

**Ameerah:** This from my neighbour’s garden. I took this picture because the leaves that have grown up are nice and beautiful and could be connected to science and the real world because, like, the real world is blue and green and science could be sun plants and recycling and could be like about how to grow them up or something, like the food. Science could be connected to the food, like with the real world as well. Can we connect them like that? she asked me. I smiled, so she stopped talking.

Ameerah took this picture of her neighbour’s garden. She turned the flash on to show the plants. This statement was about taking a photo from home to show the connection between science and the real world. Ameerah again took a photo of plants to show the real world, which is blue and green. Science in this photo is represented by ‘sun plants’ and recycling. As she continued justifying her answer, Ameerah realised that food could be related to the real world as well, not only science, as she answers in Statement Three.
Because the leaves are growing and look beautiful, she thinks they could be connected to science, and because the growing plants are green and blue, she sees a connection to the real world. Moreover, science to Ameerah is ‘sun plants’. Science in the photo, now, is more than the sun plants, discussed before. Science is recycling and food as well. Ameerah discussed the idea of recycling in the previous statement, but she began to realise that food can be connected to both science and the real world. She was previously not sure whether food could be connected to both the real world and science. She started to criticise the connection, then stopped and sat back, as it was the end of the interview.

The last statement: **Take a photo of somewhere/something that inspired you to do science.**

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**Ameerah:** Science inspired me because in the future I want to be a dentist and in science we do, like, experiments and you know like, we learned about how nature grows and like... we talk about the real world, we talk about how to do that and how the people [and] trees grow, [grow] food, anything you want. That’s [what] inspires me to do science and I love science so much. Yeah, in [the] future I want to be a dentist and science will help me a lot in [the] future.

For the inspiration statement, Ameerah did not take any photo on purpose; she was ready and very excited to talk about and explain what inspired her to study science. When I asked her to tell me what inspired her to do science, she waved her hands and said ‘Miss, what inspires me [is] none of them’, meaning the photos. Ameerah was inspired to study science because she wants to be a dentist in the future and she believes that studying science will take her there. Ameerah likes the experiments she does in science lessons. She followed ‘become a dentist’ by saying ‘we do, like, experiments’. Ameerah seems interested in practical science and maybe doing an experiment made her excited to achieve her dream. There is a recurring theme in the data, as we will see: doing experiments, it seems, is a powerful and important experience for young people. Ameerah believes that science is about learning about the growth process. She talked about how science helps us to know about growing plants and food; she does not say anything related to the human body, for example. She kept referencing examples from science lessons. It seems that everything in this statement communicates Ameerah’s understanding of the power of science, particularly for her in terms of this intention to become a dentist. ‘I love
science so much’. Lastly, Ameerah believes in the diversity of science and how science can cover a lot of topics and allow her to learn. She ended the interview by insisting again that she wants to be a dentist in the future.

**Summary:**

Ameerah is a very interesting person. She was clearly interested in and excited about science in general and about this study. During the observation phase, I saw how engaged she was with the class and the teacher. The only problem is her issue with hesitating. It seems that she does not have enough confidence in her opinions. Ameerah is not a shy person; both in and out the class she is social, and she is also an intuitive person who asks questions and responds to everyone. The science teacher tried to support and encourage her, but she was always hesitating even though she knew the right answers. I am not sure if Ameerah’s awareness of the group she belongs to is responsible for weakening her confidence. I remember how sad she looked when she told me that she belongs to the lower ability group. Ameerah’s answers in the PEI show that all of her examples are from science lessons at the time of the study. Ameerah was able to picture science and point it out but she cannot talk about it deeply or reference examples that are not in the books. Science, for Ameerah, is what she studies in science lessons. She used a limited scientific vocabulary while she was discussing the photos. However, she developed her own vocabulary to deliver her ideas. From the PEI data we can see how the real world for Ameerah is visible, while science is about she had studied in science class. Also. What she had taken from that experience was a strong sense of the power of science.

### 5.1.3. Pen portrait 3: Emma Y8

**Emma’s profile:**

Emma is 14 years old; she has been placed in the high ability group. She is from Pakistan and her native language is Bengali. Emma has two younger siblings. She told me that she lived for two years in Italy, but her father could not find a good job, so they decided to move to the UK.

**Researcher’s thoughts/observations:**

She sits in the front and focuses on and follows the teacher. She is a very competitive person; she always tries to get the right answer and to answer the teacher before anyone else. She came
to me and asked me many questions about science, science research and my studies. Emma asked a lot of questions. I did not choose Emma based on her survey results. What really made me interested in Emma was the type of questions she asked. She asked me about what my university buildings and halls look like, how I pay my tuition fees and who pays them for me. Emma’s dad is a taxi driver and her mother is a housewife. She has no relatives in the UK. She was interested in how I was able to study all ‘over the world’ when I am not rich. Emma made me think about the many disadvantaged students like Emma who do not know their future path.

The number of questions that Emma asked made me search the school archives online to find out if any measures had been taken to encourage the students to pursue science in the future. I asked the head of the science department as well, and he told me that they had dedicated a whole week to lunchtime science activities, in cooperation with a private organisation. I continued looking to see if there was an information desk or a website to ask about possible future paths at the school. I discovered on the school website that there are people who are working as work-related learning coordinators and career advisors in the school. Apparently, the school and its educators care are aware of the importance of this step. However, the number of questions I have received about this basic and vital information by children of all ages is enormous. I was surprised that the students in Year 8 and 9 still have these types of questions and I do not know if the students know about all of the possibilities and the ease of getting answers regarding the future. Some families already have members who study or work in science, but others do not. Who should these students look up to? In the corridor at the school, there are big pictures of Einstein and Bill Gates, but is this enough? I believe we are living in a very engaging era, one in which finding information is very easy, with one click, but that doesn’t lead to confident knowledge.

What attracts me to use Emma as a Pen Portrait is that she was the only participant who seemed convinced of and comfortable about her own ideas about science. Emma was frustrated when I asked for extra details; she was not annoyed because of my questions, but I think she was annoyed that I do not see science in the same way as her and that I asked about something so ordinary. She thinks I should already know it, mainly because I am a science researcher.

**Survey result:**

Emma was positive about science; she strongly disagreed that science is boring. She plans to pursue science in the future and to become a science teacher.
Science teacher perspective:

‘She is a lovely girl. She joined the school last year but she gets along very, very well. She asks a lot of questions and helps me in class by helping other girls. I would say she is a very competitive person. She is really interested in science and her family is always coming and asking about her performance. I would imagine Emma doing science in the future if she stays the same way she is now’.

The photo elicitation interview:

I interviewed Emma with Raneem. Emma was excited to talk about the photos. She recognised her photos immediately and knew which one went with each statement. She told me ‘Miss, I can’t wait to talk about my photos, even I think it is hard to explain’.

Emma was calm and confident; she seemed like she’d had this conversation before. She got angry/uncomfortable when I asked for more details. Emma decided to start with the fourth statement which was  

**No.4: Showing the connection between science and the real world.**

![Figure 12. Science has changed everything](image)

**Emma:** I think this photo shows the connection between science and the real world because there are many things related to science and most of them are in the modern world and that because in modern world science has changed everything. For example, before things we discovered, there was nothing like cars, houses, plants. There were plants but they were not discovered. They were discovered later and learned about it in more detail...

Another thing that science has discovered is how everything in everyday things work and how we can use it. Without science, that would also be nothing.

I took this picture because it mainly shows that before science discovered things in depth, there was not many things, for example houses, cars, like everyday things that we used, but science has changed everything by making new stuff, functions and technology. I think science did that because it is related to science a lot, that is, how we use everyday things. That is the way I thought this picture shows mostly the connection between science and the real world.
Emma took a picture of a wall to show the connection between science and the real world. Emma meant to show that nothing could show the relationship because everything is related to science. She used the phrase ‘the modern world’ more often than the ‘the real world’. Emma was highlighting the power of science – ‘science has changed everything’ – and said the world was plain before science.

Emma talks about the modern world; I am not sure if by ‘the modern world’ she means technology? For Emma, I guess there is the ‘real world’ and the ‘modern world’. Emma described what the modern world is or what is in the modern world by saying that ‘in the modern world, science has changed everything’. She emphasised the power and impact of science on our lives. Emma believes that science helps us to know how everything works. It sounds as if Emma really value’s science. Emma kept making the comparison between the time before and after certain inventions or discoveries. She does not mention the mobile phone or laptop, for example, or the internet. The examples she mentioned, I would say, are essential in everyday human life, like a house for living, a car for transportation and plants for food.

I do understand why she thinks that science is responsible for the invention of houses and cars, but what I do not understand is why she thinks science discovered plants. I assumed she means that science discovered how plants grow and the different types of the plants. I do not think she means the creations of the plants themselves. Emma repeated the term ‘everyday thing’, so she notices how many scientific inventions are around us and how we use them on a daily basis. I do not think Emma thought about life before all these inventions came along.
No.1: Showing how you see the real world.

Emma: I tried not to take [a photo of] the house, but if you just ignore the house in picture, the real world would be plain. It is plain [because] there is nothing, there [are] no inventions, there is no technology, it is only, like, [a] plain world.

Me: You mean plain, which is nothing? How come the real world is nothing? Explain [that] more for me please?

Emma: [The] real world is nothing because everything has been changed after science. After science came, the world has changed. Before science that I think that the real world.

Me: Okay, so before science there was a real world. What [was] the real world before science?

Emma: There [was] nothing, no invention[s], [it] was [a] plain world. Plain like... people didn't know before science what is the cause of everything, how the trees grow and [how] everything works, about the whole sky, plant[s] and everything but science has discovered many things later. For example, how plants are grown and things inside, like how everyday things work and even how we like to build the stuff.

Me: You write here [that] you see the real world as plain [with] nothing around. [Do] you mean in the real world there [are] no trees or rivers?

Emma: No, there might be some trees, rivers but as [for] plain I mean not like today. We have houses and building, cars, technology and we can go by plane. [By] plain world I mean, like, there [were] trees and rivers, I mean there [were] simple things like natur[e], but it [did not have] as much details like now.

Emma took a picture of a tree, a bit of sky and the top of a house. However, she asked me to ignore the house because the focus was on the tree and the sky. The real world for Emma is nature; however, Emma thinks that nowadays, the real world is different; the trees and the sky still exist, but they are no longer the ‘real world’. The real world now is houses, cars, buildings and science inventions, including nature.

Emma’s understanding/views of the real world are the same as the previous statement; the real world is plain. Emma defined the word ‘plain’ as the real world without science, which has no
inventions or technology, which, as a result, makes it plain. She believes that science changed everything. Originally I thought that are two versions of the real world: the real world before scientific inventions and the real world after scientific inventions. The real world is in the past; we now live in the modern world. Even though she called the real world after scientific inventions the ‘modern world’, Emma considers the real world before science to be nothing and she said ‘[the] real world is nothing because everything has been changed after science came.’ Emma explained further why the real world is plain. It is not only because in the real world, there were once no inventions, the world also was lacking information and knowledge before science. From Emma’s perspective, science taught us everything; she used the word ‘everything’ to insist on the importance of science and how science is still contributing to changing the world. I was not sure I understood what Emma was saying in terms of defining the real world. I asked her again if the trees and the rivers represent the real world. Emma replied that by ‘plain world, I mean like, there [were] trees and rivers, I mean there were simple things like natur[e] but [there was not] as much detail like [there] is [now]’. From Emma’s perspective, science is the details about everything, from information about the world to how to use it.

No. 3: Take a photo to show how science is disconnected from the real world.

![Figure 14. There is nothing disconnected from science](image)

**Emma:** I took this one. I think there is nothing [that is] disconnected from science. Science shows us all about the world, the world that we are living [in], how everything works. So, without science, everything [is going to] be plain. By plain I also mean this plain, like, is going to be nothing at all. I don't think there is anything disconnected from science because, like, everything that we use, we see something, somehow, [is] going to be related to science.

Emma here took almost a similar photo to the one from her first statement, the statement about showing what the real world is. In this statement, showing the connection between science and
the real world, and in her tone of voice, Emma stated her strong belief that there is nothing [that is] disconnected from science. Emma was defending her belief by explaining the significance of science: that science explains the world that we are living in. As well, science shows us how everything works. Emma thinks that everything is related to science, even if we do not exactly know how.

Emma explained again what she means by the word ‘plain’. In this statement, the word ‘plain’ means without science; we would not have information about our lives and the world would be plain. I really want to mention again how Emma was very certain about her perspective towards science. Emma is steadfast in her belief of a plain world without science. For me, it seems that there is an issue of time underlying her statement. The real world existed before science. So for her, there is no ‘real world’, now. There is only the modern world.

**No. 6: Something that inspired you to do science.**

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<td><strong>Emma:</strong> For this one, something inspired me to do science, it is everyday objects, [how] everything works, like how our body works, how, like, the world is, that science inspired me to do a lot of things, how, like, whenever I see the sky. I feel like there is so much to learn about from the world because everything is related [to] science. There [is] not [going to] be anything disconnected [from] science and whatever it is [is going to] be really interesting.</td>
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The last statement is about what inspires young people to study science. With someone very interesting like Emma, I was really excited to know what her inspiration was to study science, especially as she wants to pursue science in future. Unfortunately, Emma had no photo to use for inspiration. Emma considers everything in everyday life as an inspiration for her to pursue science. She sees that science provides the possibility of learning about everything, which means that curiosity is worth having. She can look at anything and trust that science has a way to unlock the detail for her, and an understanding. Emma believed in the power of science and believed that if she looked at the sky and had a question, she would find the answer in science. Again, she mentions how is everything is connected to science and that nothing is disconnected. Also, she believes that science is impressive and that anything she wants to explore is going to be interesting.
Summary:

Emma is a very interesting student. She is not a shy student; she introduced herself to me on day one. She asked me a lot of educational and personal questions. Emma seems to take her future path seriously and her parents do too. The science teacher told me that her parents are always coming in to check on Emma’s performance in school. Emma’s PEI was challenging for me. She is so smart and kept asking many questions. She was worried about tuition fees for university; she even asked me to explain what the classes at university look like. Imagination seems to be a big part of Emma’s life. In the beginning, I could not understand her perspective on how the world is plain. Emma’s body language is very strong; she was so confident and sure about her ideas. She was not waiting for any signals of agreement about what she is saying. However, she is different and her perspectives and the way she understands things is different from the rest of the participants. Science is an important aspect of her life. Emma clearly loves and values science.

5.1.4. Pen portrait 4: Maryam Y8

Maryam’s profile:

Maryam is 14 years old. She is from Bangladesh, and the language spoken at her home is Bengali. She has been placed in the high ability group in science class. According to school data, Maryam’s attainment level has massively improved since Year 7, but they did not provide me with any reasons for such an improvement.

Researcher’s thoughts/observations:

Maryam sits in the second row in the classroom; she is quiet and has well-presented science notebook, by which I mean the science notebook is up to date, coloured and decorated very nicely. She follows along with the teacher and engages very well with the questions and activities. In the beginning, I was not thinking of including Maryam in my study; for me, she was not different from a typical student until I saw the survey data results. I was surprised as Maryam doing very well in class and engaging very well with the teacher and other students. However, she was not excited about science lessons, and she does not want to do any activities related to science outside the classroom or to do a science-related job in future. So, I decided I wanted to know more about Maryam’s perspective towards science. It is a surprise for me, as
a science teacher, to have a student who does very well during class but is not interested in doing any science in the future, nor is excited for science lessons.

Survey result:

Maryam strongly disagreed with the prospect of doing more science at school, like joining a science club. She was also disagreed that she would work in a job that requires science in future. She believes they are studying an exciting thing in science lessons, but she does not look forward to them. Maryam said that she watches science programs on TV but is opposed to joining any science clubs in school.

Science teacher perspective:

According to the science teacher:

"Maryam is a very sweet girl, as you have seen, she is engaging very well with me, she helped the other students as well. She is a quiet and not talkative person. She is doing very well on exams and quizzes; she shows a huge improvement compared to last year. I like Maryam”.

The photo elicitation interview:

I had to interview Maryam alone, because she was sick and absent for almost two weeks. I asked her if she was okay being interviewed alone, and she smiled and said ‘yes, Miss, I am okay to do it alone’. Maryam sat next to me; she was a little bit nervous. I felt that she was dealing with the situation like it was an exam. I reassured her that this is not an exam and that she was free to leave at any time, and that no one else would listen to what she had to say. Moreover, I let her know that I did not mind if she didn’t want to answer my questions.

Maryam wants to start with the second statement, **No. 2: Showing how you see the real world with science in it.**
Maryam: I want to start with this one. The real world to me is more, like, about nature and more about natural stuff, and having a car is part of everyday life, so [if] you drive it is like an invention, so [it] is part of science. Together [they are] like my real world with science in it.

Me: So, in this photo the science is the car, and what is the real world?

Maryam: The trees and outside.

The picture is not clear; it is a tree, a car and a house. Maryam claimed that ‘nature’ and ‘natural stuff’ are the real world while the car is ‘like an invention’ and, therefore, represents science. This ‘natural’ stuff alongside the car represents the real world. Maryam sees the car as a part of everyday life, and at the same time, the car represents science, because it is an invention. Maryam sees science as being about inventions. She used the term ‘my real-world’ when she talks about her reason for including a car. Maryam appears to view science from the perspective of what she uses in everyday life. The car was an example of science in her world. She does not talk about her positions related to the real world or science. The outside and the trees are the real world. As I said before, I did this PEI with the students alone, not in pairs. I know I should have asked more, but this was the first question, so I tried not to ask deep questions. So far, Maryam appears to be similar to most of the girls who understand this question as bringing two things together in one photo.
No. 1: Showing how you see the real world.

Maryam: This is the real world, because the real world includes the house. This is part of our life, and has nature in it and we live in it like your real world.
Me: So, if I asked you what is the real world in this photo, what would it be?
Maryam: The real world is where you live, your environment, so, like, houses.

The picture might not be clear because of the sunlight. It is supposed to mainly show houses. Maryam’s real world is the houses and where we live. The picture is not about the houses only; she made sure there is a tree in the picture, because the real world has nature as well, which I assume she uses to describe the environment, like most of the participants. Maryam’s answers were short, and she was a little bit nervous, however, she was sure about what she had chosen to present her idea. She did not mention, for example, the family or friends or relationships in general, like other participants. Maryam seems to talk about stuff, the things we use to facilitate our life. Science, to her, from the previous statement, is about inventions like cars, not about nature. She did not mention any other examples, and during the time of the study, they were studying the units of motion and acceleration. Maryam appears to again be positioning herself in relation to the real world and talks about the real world as something belonging to us by using words like ‘your real-world’ and ‘we live in it’.
No. 3: Showing science as disconnected from the real world.

Maryam took a picture from her bedroom window. She wanted to take a picture of the sky only. The sky here represents space, or, like Maryam said, ‘the base of the world’. She thinks the sky is part of the real world. She distinguished between the sky and space, which shows a great imagination. She thinks the sky is part of the real world, whereas space is part of the world. The sky and space are not connected to science because they contain nothing made by humans, which maybe means she thinks science is about inventions and human-made stuff only. Seeing a disconnection between the real world and science in this way is not new; it is a shared idea between several of the participants. Some of the young people think anything that is man-made does not belong to the real world. In contrast, the car and other inventions are science. This shows how much science is disconnected from the real world for some young people, and how they think of science as being about things that are human-made.
No. 4: Showing a connection between science and the real world.

Maryam: I got this one because it has the wires and the houses, which is showing the real world. We use the internet every day and electricity, and . . . if you went home and there is no internet, no lights and everything . . . you, like, because this [is] how you live your life and you need the electricity, so this [is] science with the real world in it.

Me: So, in this photo, the houses are the real world?

Maryam: Yeah, like, you need the electricity; you need this in your house. You need those in your life. So, your house is in your life.

The picture, as Maryam explained, has a wire and houses to present Maryam view about the connection between science and the real world. She was aiming to take a picture of the wires, as the wires are related to the electricity and the internet. In this statement, she is considering people’s lives as the real world, and their houses are the real world, too. Maryam starts the discussion by saying that the house is the real world and the wires are science. Having a picture with wires and the houses for Maryam represents the connection between the two. It is not about the wires and the houses; the connections are people’s needs for the services required for living in a house and having the internet. She describes the human needs of using the internet and lights as the real world. Houses and the other things that people need are the real world.
No. 5: In your home, something or somewhere that shows a connection between science and the real world.

Maryam: *I got this one because of the car again, because this [is] just like the part of the real world and science in the car and how [the] car [is] constructed and stuff: it is just related to your real world. That is in the real world and that is in science.*

The picture is not clear; however, Maryam wanted to represent the car. In this statement, Maryam considered and talked about her own life as an example of the real world; she kept saying ‘your’ and ‘my real world’. She does not mention nature or the sky in this statement, even though the picture has a tree and shows a little sky. Maryam again used a car as an example of science. Science relates to the car because the car has been human-made and constructed. Again, I would like to mention that at the time of this interview, the students were studying a unit about motion and speed.

The statement asked students for a picture from home showing the connection between the real world and science. Maryam took a picture of her family car, as she told me before we started the PEI. From Maryam’s perspective, the car is science and herself and her family life are maybe the real world. Or, maybe she took this photo because the car is outside parked in front the house, near a tree and beneath the sky, which are part of the real world, based on the first and second statements. The family car is an example from home of science in the real world.
Maryam took an unclear picture of a big tree; the tree represents nature. Maryam said [that] what inspired her to do science is the desire to know more. She wants to know and find out about the human development process. As well, she is interested in knowing how humans change, also. Her interest is not only about humans, but she also wants to know about the world as well. She seems interested in knowing more about a lot of things here: humans, nature, species and the world, which absolutely the opposite of what she said in the survey. I do not know if she answered this way to make me happy because she knows me as a science teacher, but her answer is precisely the opposite of the survey results. The possibility is that she is interested in finding out more about living things and their development, and that this is the inspiring part of science. Technology and inventions are not in this picture at all.

Summary:

Maryam was an interesting participant for me. I was surprised when I interviewed her; she holds a very positive attitude towards science, but based on the survey results, I thought she was one who held an especially negative perspective of science. When I did the observation, she was an example of a good student. She has a completed, beautifully decorated science
notebook; she moved around to help other students. She was engaged with the teacher all the time.

I do not know if she was just doing well in science for the sake of high grade and to be with the high ability group. However, Maryam’s PEI was not that deep. She kept repeating the same example, which was the car. Interestingly, the two examples she brought, the car and the internet, are from science lessons that were going on during the time of the PEI. However, the way that she sees the disconnection between science and the real world is interesting, and she was not the first one to think that science means human-made things.

The Maryam I know from science classes is very different from the Maryam I talked to during the survey. In science class, Maryam really cares about science, which she shows by looking after her science notebook, engaging in class and helping other students. On the other hand, she believes that science is boring, and she does not want to do any science-related job in the future. Maybe because she cannot see how science is connected to her life and sees it as only a subject in school.

5.1.5. Pen portrait 5: Mila Y9

Mila’s profile:
Mila is 15 years old. She is White British. She is in Year 9, and she had been placed in the middle ability group in science class.

Researcher’s thoughts/observations:
Mila sits in the back of the class; she wears a short skirt with full makeup and straight hair every day. I attended many science lessons with Mila’s class, and she was always quiet; most of the time she was busy doing something while the teacher was talking. While she was busy, she was also following the teacher and answering his questions at the same time. I tried to see what she was busy doing; I thought she was writing some notes from the lessons, but in fact she was drawing. I do not have data about Mila’s personal life like I do for the other participants; she did not ask me anything personal or share any details.

Survey result:
Mila disagreed with 14 questions out of the 17 in the survey. She was strongly opposed to doing science in the future, although later on in the PEI, she said she wants to be a cardiologist. Mila’s interest in being cardiologist came from her passion for boxing after school; she enjoys the sport very much. She strongly agreed that science is boring and only agreed that the class was studying an interesting thing in science. According to Mila’s survey result, she does not seem interested at all in science; however, she is doing well in exams, and she has been placed in the middle ability group.

Science teacher perspective:

I sat with Mila’s science teacher for a short interview, mainly to explore his beliefs about Mila. I showed him Mila’s photos. I said to him: ‘Mila’s answers were different’. He replied: ‘If you looked at the class itself, she is different, isn’t she? That is the thing: she’s got more of a personality than a lot of the other girls; it could be cultural as much as anything else’. He was shocked when I told him about Mila’s belief that science is boring. He responded:

‘Oh really, that’s a shame. She [has] been quite a good scientist. She is not there yet with her enquiring mind. If you look at a lot of the others in the class like Laylah and Ayah, they [are] constantly asking questions, but Mila [is] not, she is simply sitting and allowing the stuff around to happened. I may need to challenge her next year. She has the ability. I wonder, sometimes, what happened. Students find [their own] level when you are in a setting and it might be that she is actually far more intelligent, but going back to the ability to answer exam questions in the group, she is [bored]. Is it a thing of ‘I am not learning anything new’? So, she might be a classic case of she is not working hard, because she does not find it interesting, but she does not find it interesting because she [has] not been trying the hard work. This is the reason why we find science interesting [in the] first place, so it is a circle. I am not surprised with Mila’.

The photo elicitation interview:

I interviewed with Mila alone, as the girl I was planning to interview with Mila did not bring the camera back to me. Mila came to the science assistants’ room for the interview after the school day was finished. She was smiling, relaxed and ready to talk. As I mentioned before, I let the participants choose the order of the photos they wanted to talk about, and Mila was the only participant who decided to follow the original order. Therefore, the first statement was about the real world.
No. 1: Showing how you see the real world.

Figure 21. Money

Mila: I put this because thought all about [the] economy and money in the world, all the different restaurants. how all the jobs [are] giving people certain amounts of money, so the world [is] really about money and earn[ing] or spend[ing] it [on] taxes [and] shops and that’s why I picked that one.

Me: Is this include[ing] people?

Mila: Yeah, all people always go to shops to finds job or to spend the[ir] money.

Me: So, you think the money is the real world?

Mila: Yes.

Mila’s photo was from a computer monitor, and the photo shows a busy street full of restaurants and shops and also has a big screen advertising on it. Mila thinks the economy and money are the ‘real world’. This picture shows that. Mila, here, is talking about the human needs of having money and spending money. Money is an essential topic for Mila, so she sees the world as relying on it. Money is essential and money meets people needs. She did not take a photo of money notes as she views the money from an economic perspective; to her, it’s all about what we can do with money or why we need money in life. Money has meaning in Mila’s life; it is about meeting the needs of people. She thinks people should also be included in real-world pictures because they are the ones who spend and earn money. Mila did not mention science at all in this statement; receiving a certain amount of money is the real world. I am not sure whether finding a job and earning money could be a personal struggle or an issue for Mila.
No. 2: Showing a connection between science and the real world.

Mila: Plants because [of] photosynthesis and other things. The plants and nature [are] the actual world and the ground is made by science.
Me: What [is the] science in the photo?
Mila: [It's] like photosynthesis, plants and living organ[isms].

Mila took a photo of the branch of a tree to show how the real world is connected to science. Mila views the plant as representing science because of photosynthesis; there is a big chance that this may come from science lessons. In this statement, Mila thinks the plants and nature represent the actual world, while the ground is made by science. The real world and science are connected because plants and nature grow from the ground.

She thinks plants and nature represent the actual world; she did not use the term ‘the real world’ and I did not ask why. Perhaps there is no significant difference between the words ‘actual’ and ‘real’, but it shows how Mila is different from the other participants. However, in this response, Mila ultimately sees the real world in different way in comparison to the previous statement.
No. 3: Showing how science is disconnected from the real world

Mila: This one [I chose] because obviously you have air and things like that and in order to do science, you got like gases; you cannot see gases a little bit, that it is in the real world . . . but is not really connected to the real world, it is just around us. [I] don't think about it every day.

Me: What do you mean [it] is not connected?

Mila: I mean, it's something not a lot of people notice. You wake up every day and it is around you. [You are] just used to it.

Mila: [Does] that mean gas and air [are] related to science?

Not really. I don't really think that is connected to science. Gas [is] connect to science, but the air is not, [the] air is just around us and everybody [is] used to it, but the world [is] made through science. It is still a part of science.

Mila took a picture of an image on a computer screen. She meant to show the air, so the picture is from a skyscraper. The air is the real world, even though we cannot see it; she tried to explain the idea that the air is not visible, which made the air not connected to the real world. The real world, at this point, is the world that is present to us.

Then she connected only gas to science, not the air. She considered the air and gas to be different. They are similar in terms of visibility because they are both around us and we are used to them both. However, the science part of the air is gas. The real world, which is the air in this picture, is not connected to science because no one notices it and we are used to it. Her words here suggest that Mila thinks science should be noticeable. Again, she believed that gas and air are not really connected to science. Lastly, Mila thinks the world is made through science, so it belongs to the air, while the gas is part of science. Mila here perhaps thinks the connection between the real world and science should be noticeable, like the growth of plants. However, as we cannot see it, the air around us is not connected to science. I assume the idea of the gas belonging to science came from science lessons.
No. 5: Something from home that shows the connection between science and the real world.

Figure 24. Genes

Mila: I took a picture of my cousin, because I think about genes showing the connection between science and the real world, because the real world [is] actually about people, because science made people, like the x and y and chromosomes and genes that [are] in your body, and all the blood and the heart. So, this is showing the connection between science and the real world.

Mila took a picture of her cousin as an example of the connection between science and the real world. Science is the genes in her cousin’s body in this picture, and now the real world is people. Mila’s cousin shows the perfect example of the human body from outside and what is going inside. Mila mentioned in a previous statement that she believes that science created the ground and, through this photo, she shows that she believe that science created people as well. It is worth mentioning that the connection between science and the real world in this statement may come from science lessons, as at the time of the PEI, they were studying genes and chromosomes.
No.6: Something that inspired you to do science.

Mila: This [is a] growing plant my sister just planted, because it is showing how [it] is growing with [a] certain amount of water and the air, and if you think about it, how is this actually happening and the world planting, growing or how the baby in science developed bones and things inside, you would say what. So, this something [that] inspired me to do science.

In the last statement, Mila took a picture of her sister’s project, as she told me. Her sister was trying to grow plants at home. The growth and change process in [the] plants inspired Mila to study science. She wanted to know more about the amount of water and the air the plant needs to grow. Mila wants to know in detail what is happening with the plants. As a result, by doing science, she can find the answers. Then she talks about how the baby grows and develops bones inside the female body. The change and the growth and the desire to know more about these processes are what drive Mila to study science.

Summary:

Mila is an interesting person. She is doing very well in science class, but she is not interested in science at all. However, she wants to work in a science-related job in the future. The science teacher was shocked when he saw Mila’s survey and PEI results. I chose her after I observed the class many times. She was drawing during the science lesson and engaged with the teacher as well. During the PEI, Mila seemed interested in science, and she also seemed to give the task enough time to think. She was knowledgeable about everything she talked about during the PEI. I do not know if Mila sees a difference between school science and the science that creates everything. Visibility was an issue for Mila; she thinks the air is not connected to
science because it is not visible, and because we are used to it. The curiosity and the desire for knowledge and knowing that, through studying science, you can find an answer, is what inspired Mila to study science. I would agree with the science teacher that Mila thinks science is boring; perhaps this is because she thinks she is with the wrong group and deserves to be with the high ability group.

**Overview for all Pen Portraits:**

As I mentioned before, I was not originally to do Pen Portraits. Nevertheless, after I did the thematic analysis, I noticed how each individual is unique. I felt like some of the participants' interviews should be shared and discussed further. The thematic analysis in the next chapter will show the sharing of ideas and an understanding of science. However, if we look deeply at the interviews as a whole, we see a different story. I remembered that body language was fascinating; that young people sometimes struggle to deliver their opinions. They can be very hesitant with one statement and excited with another. Sometimes the participants defend their idea passionately, while others present their perspective calmly and want to move on to the next photo fast. Even with less-than-articulate language or appropriate vocabulary, they were open to participating and presenting their opinions and understanding. This shows how they can be very reflective and have the knowledge to discuss their idea. Some gave short, superficial answers, but by saying ‘superficial’ we do not mean to judge their answers, we just believe that, at this age, young people can be more critical. By studying each case, we can see how some participants referenced examples from their science lessons much of the time. By looking at these five Pen Portraits, we can also see how individuals have many different ideas, some of which may be contradictory.

As a science teacher for years, this research has opened my eyes and mind to a whole new perspective. I had a lot of ‘aha’ moments; I wish had the opportunity to do follow-up interviews to ask more questions. The way the participants moved from one photo to another and explained the science in the photo was significant. It showed that we, as science teachers, really do not know what is going on in our students’ minds. During science lessons, we invest our efforts in developing their understanding, but we do not know if it makes sense to them or not. We ask if the lesson was understood, but we never go beyond whether it makes sense to learn more about how students make connections to their everyday lives. The examples of metal, medicine and air were seen as being disconnected from science because students in science do not see
the connection with real life, which was a shock for me. I presented this idea of the disconnection between science and the real world at the International Conference of Science Education called New Perspective in Science Education in Italy 2019 and it had a huge impact on the audience. We were surprised, because we never ask students if the example makes sense in terms of relevance. All of the participants had really interesting ideas that we would not know about without this process, and the images really helped as a vehicle for the communication of those ideas.
5.2. Part two: Thematic Visual Analysis

Introduction

This chapter is the main empirical chapter of the thesis. The purpose of this study was to explore and understand young people’s perspective of science in relation to their world, which we have referred to as the ‘real world’. The study is based on photographs generated by the participants in order to get responses to four given requests. The requests were:

1. Take a photo from anywhere showing how you see the real world.
2. Take a photo from anywhere showing the connection between science and the real world.
3. Take a photo from anywhere showing how science is disconnected from the real world.
4. Take a photo in your home of somewhere or something showing the connection between science and the real world.

We used photo-elicitation interviews to explore the topic in-depth and to understand young people’s unspoken and hidden opinions about science. We started with an assumption that young people see science only as a subject in school which is utterly separate from their real lives, which may be one reason why young people are no longer interested in science.

In the literature on PEI, I found that little attention was paid to the techniques of data analysis for visual data, with most attention given to the interview data, in the form of spoken words. To help tackle this, we decided to explore the data from two angles: through a discussion of my reflections during the coding of visual data and through applying a Pen Portrait technique to five out of fifteen participants in order to understand their full, individual viewpoints concerning their connection with science.

In order to analyse the interviews and observational data, initial coding was completed on all photographs. Analysing photographs taken by participants was totally new to me. Even though previous researchers have used methods such as coding, sorting, mapping and content analysis on their visual data (Hume et al., 2005, White et al., 2010, Clark and Zimmer, 2001, Aldridge, 2012), there was very little description available of how these techniques can be accomplished.
For this study, an approach called thematic visual analysis by Thomas and Cook (2006) was used, which involves combining elements of content analysis and thematic analysis, starting with inductive coding. Also methods that unravel individual images in detail, such as semiotics (Barthes, 1977, Barthes, 1981), and methods such as coding and content analysis allow researchers to analyse large numbers of photographs in a reasonably short period of time. I uploaded the photographs into NVivo 11, where sections of each image could be highlighted and given a descriptive ‘node’ in the same way as written data. I used a system of ‘open’ coding in order to create an initial coding frame. The nodes were created in response to the content of the PEI, instead of being fixed/prearranged by myself. When all the photographs had been coded, ‘open’ nodes were grouped into ‘tree’ nodes, which were developed to become thematic categories. The next section will present the resulting thematic visual framework. As well, we will present each photo statement with the thematic categories generated from it.

5.2.1. The first photo statement

1. Take a photo from anywhere showing how you see the real world

We asked the participants to take photos from anywhere to capture how they see the real world. Someone could argue that the term ‘the real world’ is vague, however I did not receive any requests to define what I meant by it; it seemed something that everyone understood. However, the themes that emerged from this request were not expected. They show the variety of views each participant has about the real world and indicate that, even if the young people present the real world using similar photos, after the PEI, the participants’ viewpoints appeared very different. The way they saw the real world was completely different from one another, no matter how similar their photos might have looked. The first statement generated five themes.

According to the participants, the real world is:

1. Only nature.
2. Our everyday needs.
3. Plain.
4. Our relationships with family and friends.
5. Reality.

The first theme is: the real world is only nature.
Nature was the most common and repeated word participants used when asked about what the real world is. The participants took pictures from different sites and angles to convey the same idea, which is that nature is the real world. Based on the participants’ photos, nature came in many forms; for example, trees, plants, bushes, flowers, birds, grass, clean air, etc. The box below includes all of the pictures the participants took as examples of nature. We are going to present each photo in table with an introduction about the participant, her photo and her response.

![Participant’s set of seven photos for the first theme only nature.](image)

This first group embraced the idea that the real world is nature. They were quite sure about their views, which made them different from the rest of the participants. The confidence they showed when presenting their short answers, along with the facial expressions this group had, made it appear as if they were explaining something that is well known and does not need to be questioned: the real world *is* nature.
When the participants explained their views, especially in this group, they expressed them with confidence. Their body language showed that they were very certain about the topic they were discussing. I notice that they took this to be well-known information, because when I asked them for extra justification about why they thought this, the participants got confused and were clearly not expecting to have to explain their choice. I eventually stopped asking for extra details, as this question often came at the beginning of each interview, which may have affected their answers to the following questions and also may have affected the time limit. The participants may not have had any clear justifications for why nature is the real world, although to me, it seemed like I was asking about something that they had taken for granted.

Olivia is in Year 7 and was placed with a low attainment level group. She is from Pakistan, so the language spoken at home is Urdu, and she speaks English as a second language. Olivia thinks that science is boring. During the PEI, Olivia was relaxed and confident, which allowed me to ask more questions, but I think the language barrier was an obstacle.

Figure 27. Olivia’s “only nature” photo for her first photo elicitation interview

| Me: Why does this photo represent the real world? |
| Olivia: Because it talks about how you see the real world, so I thought [of] nature, so I took picture [of] the garden. |
| Me: What do you mean by nature? |
| Olivia: [Silent]. |
| Me: What kind of nature is in this photo? |
| Olivia: Like flowers and trees and plants. |
| Me: Does that include people and animals? |
| Olivia: [Thinking for a few seconds] Yeah. |
| Me: Does that include water as well? |
| Olivia: I am not sure. [Pause] Yeah, including water. |
The garden at Olivia’s house represents her view of the real world. She tried to take the picture to show the flowers, trees and plants. Olivia intended to take the picture with flash on. She turned the flash on to make sure the photo would show the flowers. The picture includes many features, like the sky, the street lamp, other houses and the garden fence. Olivia did not say, however, anything about them; I assume she did not notice them in the photo. Olivia was focused on the trees, flowers and plants. Olivia was sure, as I mentioned at the beginning, that nature is the real world and that this is well-known information.

Olivia stopped describing the real world, and I was looking for more details, which forced me to ask more questions. I wanted to know more about whether nature is the plants or if other features are included, like animals and people. I therefore asked about people and animals and whether she thinks they are part of the real world or not; she agreed that people and animals are part of the real world as well. I followed that question up by asking about the water. Olivia got confused and hesitated in saying whether water is a part of the real world or not; after 20 seconds she said yes, water is also part of the real world. I did not ask why, because I did not want to stress her out anymore, so I moved on to the following statement.

**Aria** is in **Year 7**; she was placed with a high attainment level group. She is from Poland and speaks English as a second language. Aria thinks that science is not boring, and she enjoys science very much.

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<tr>
<th>Me: How do you see the real world in this photo?</th>
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<td><strong>Aria:</strong> I see the real world [in] like a lot of plants and a lot of nature, but I also included the bin. Because if you see the real world, I can’t see people with it; sometimes [it] is a bad thing in the real world, because people just throw [their] trash [away] in nature and it [is] just not respectful.</td>
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<th>Me: What kind of nature exists in the real world?</th>
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<td><strong>Aria:</strong> [Different] kinds of trees and bushes and grass: that is the basic thing. And then the flowers. And then there is some special birds over there. they might distinguish in any time but like there is a lot of birds and bees and animals living there, so [it] is really important</td>
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Figure 28. Aria’s “only nature” photo for her first photo elicitation interview
Aria took this picture in the schoolyard. The picture has trees, grass and bushes; she intended to include the bin as well. Aria included the bin in order to talk about an environmental issue, which I think was a vital topic for her. I assume that, because of her facial expression when answering, she was despondent about how people mistreat and disrespect nature.

Mentioning this issue might be evidence of her interest in science. Aria excluded human beings from nature, so I decided to ask more about what nature is for her. Aria had her own definition of nature; she thinks that plants, trees and bushes are the basics of nature. I assume that by ‘basic’ she means they are everywhere. After these basics, she included the flowers, followed by special birds, bees and animals. It seems that, for her, nature has different levels, from the ‘basic’ to more complicated levels. Aria finished her sentence by asserting how important nature is. She seemed to really care about environmental issues.

Layla took a picture of leaves. The leaves represent the real world because they are a reminder for Layla of the job that the leaves do. She sees the leaves are representative of the real world because they keep the world clean. Layla’s idea is that the leaves keep the air clean by consuming carbon dioxide. Moreover, the leaves do not cause any problems. Layla did not mention any example of the problems that the leaves might cause. However, when Layla mentioned that the leaves consume carbon dioxide, she did not explain much; it seems like she had missing information. In the end, for Layla, the leaves are both the real world and science.

<table>
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<th>Layla is in Year 9; she is Pakistani, and was placed with the high attainment level group. She strongly disagreed that science is boring, even though she doesn’t read anything related to science outside of school and she does not want to be a science teacher.</th>
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| **Me:** How do you see the real world, Layla? | **Layla:** This a picture of just leaves and I took this picture because, as Ayah said before, is remind us of photosynthesis and also helps the world [and is] linked to the world by keeping the world very clean and helping human beings to breath and not cause any problems, so this consumes the carbon dioxide amounts. So that why I think this is the real world and represents science as well. |
| **Me:** So the real world is the plants/leaves? | **Layla:** Yeah, the environment. |

Figure 29. Layla’s “only nature” photo for her first photo elicitation interview

Layla took a picture of leaves. The leaves represent the real world because they are a reminder for Layla of the job that the leaves do. She sees the leaves are representative of the real world because they keep the world clean. Layla’s idea is that the leaves keep the air clean by consuming carbon dioxide. Moreover, the leaves do not cause any problems. Layla did not mention any example of the problems that the leaves might cause. However, when Layla mentioned that the leaves consume carbon dioxide, she did not explain much; it seems like she had missing information. In the end, for Layla, the leaves are both the real world and science.
Photosynthesis is science, and the environment is the real world. It depends on how she sees the leaves or the attention she pays to the job of the leaves.

Tina is in Year 8; she was placed with a low attainment level group. She is from a black background. Tina was friendly and smiled all the time. She was a little upset about the fact that she has been placed with a low attainment level group. Tina wants to be a lawyer and she is strongly disagreed that science is boring.

Tina: I see the real world as nature, and the real world is like nature without this modern technology and things like this. I feel like the real world is nature and is not like technology and things.

Me: What do mean by ‘technology’?
Tina: I think technology does link to science. Science is like computers as well, because [that] is how [it] is linked to the real world. Science is like a bond that brings technology and the real world together. For the real world, [it is] just the nature and all the natural resources that we got.

Tina took a picture of small green area on the side of the street to present the idea that the real world is nature. She did not specify what nature is in the photo. Tina assumed that everyone knows what the real world is. As I mentioned before, this group of girls think that nature is the real world and that that is well-known information, so they did not explain their thoughts or give any details.

Tina thinks that technology is linked to science, but technology is not the same as science. She then gave the computer as an example of how science is linked with the real world. Tina kept repeating the word ‘technology’ during the interview; I initially thought that technology was science for her, but apparently it is different. Tina sees science as the bond that brings technology and the real world together. Maybe this means that she knows science is a huge subject and cannot be limited to one word, like ‘technology’. She seems, however, to really value science.
Reem is in Year 7. She is from the Middle East; specifically, Syria. Reem recently moved to England. She refused to speak in Arabic; her English was minimal, but I think she refused to speak in Arabic because we had another participant with us, and she wanted to show her peer that she can speak English. According to the science teacher, Reem is a very competitive person. The survey shows that she thinks science is boring and she does not want to do any science in the future.

Reem thinks the real world is nature. She did not specifically say the word ‘nature’, however she said ‘plant’, even though she took a picture of trees. The reason that trees are the real world is because they are important. To Reem, the importance of the trees or plants comes from their job of providing us with oxygen.

Reem had the shortest answers of the group, I think, mainly, because of the language barrier. She was nervous, and I did not ask any further questions in order to keep her calm. Reem reminded me of myself when I started studying abroad. I got very anxious if I did not know a word in English, so I protected myself by giving short answers and staying quiet. I therefore did not push Reem any further. She refused to speak in Arabic, so I respected her choice and we moved on to the second picture.
Eva is in Year 7. She was placed in the low attainment level group. She is from Bangladesh. Eva speaks English as a second language, and her English is broken. I chose her because Eva strongly agreed that science is boring, and she did not enjoy science lessons.

Figure 32. Eva’s “only nature” photo for her first photo elicitation interview

Eva: I took this picture of the birds because with trees, birds live in the trees, also trees give us oxygen and [are] related to science and animals.

Eva took a picture from the park to show the real world. She took a picture of the trees to show how the trees play a significant role in humans’ and animals’ lives. The trees are important, as birds live in the trees. As well, the trees give humans oxygen. I assume she meant that the trees or nature are the real world, but she did not say that. Eva claimed that the importance of the trees had to do with both human beings and animals, as they provide a home for birds and oxygen for humans.

Reflection

This shared idea about the real world as nature leads me to suggest that this is a cultural model. However, the details of this model are not yet clear. I was searching to understand what the word nature could stand for, because even though many of the students used the same word, each had her own way of explaining it.

According to the Oxford dictionary, the definition of the word ‘nature’ is ‘the phenomena of the physical world collectively, including plants, animals, the landscape, and other features and products of the earth, as opposed to humans or human creations’. I also that a synonym of the word ‘nature’ is the natural world, which is defined by Oxford dictionary as ‘the living world, mother nature, creation, the world, the environment, the earth, mother earth, the universe, the cosmos, natural forces’.
The participants, therefore, see the real world as nature or the natural world, or as features belonging to the natural world: photosynthesis, growth, plants and trees, animals and oxygen. The seven participants consider the real world to be nature. However, they associate slightly different ideas with this idea of nature. One thing they do have in common is that they more or less exclude technology and human beings from the real world, though they differ in terms of the value of nature to human beings. Some consider nature to be of service to human beings, whereas others see human beings as dangerous or detrimental to nature. For example, it is striking that there is a strong similarity between the first dictionary definition and Aria’s views about people not being part of nature but being potentially detrimental to it. There is so much here that could be further explored, but the time constraints of the interviews meant that this had to be balanced against the need to ask the pupils other questions.

The second theme in terms of how students see the real world is:

1.2. Our everyday needs

The second theme was about our everyday needs (e.g. a car to drive, a floor to walk on, money to buy stuff with, water, houses, etc.). Some participants see the real world in a kind of materialistic or practical way. As you can see below, the photos without the context do not seem to share the same perspective, which is everyday needs. However, the PEI shows the clarification of the reasons of each photo stand for, and also shows that these photos belong to one theme: ‘our everyday needs’.
Bella in Year 7. She is Somali. She was placed in a low attainment level group. Bella speaks English as second language. She strongly agreed that science is boring.

Bella: Because in the real world we have a floor to walk on. If we didn't, then I don't know. We need, like, the environment, that’s why I chose this for the real world.

Me: Explain that more to me.

Bella: There is a car and a lot of people have that, there is street and some places to walk and that [is] what we need to stand on, the environment. Because the environment [is] the trees and the sky.

Bella told me she took this photo from the top floor of the bus; she was super excited to use the camera. Bella thinks owning a car and having a path for pedestrians comprise the real world. I asked for more details as to why we need the car and the floor and Bella said ‘if we do not have floor to walk, then what?’ and she flipped her hands and raised her shoulders and eyebrows. She also used the word ‘environment’ instead of nature. Bella sees the real world as what she used or needed at the moment of taking the photos. She seemed to look around and explain what she sees at that moment. She does not seem to have a fixed definition of what the real world is. However, throughout the whole interview, she relied on consciousness and what she could see and touch as ways to explain her relationship with science. I assume she made the connection to science visually and in the moment.
Mila is in Year 9. She is white British and she was placed in the high attainment level group. Mila strongly agreed that science is boring, and she strongly objected to doing anything related to science in future.

| Mila: I took this photo because it [is] all about [the] economy and money in the world; all the different restaurants, how all the jobs give people [a] certain amount of money, so the world [is] really about money and earning or spending it on taxes, [or in] shops.  
Me: Does this include people?  
Mila: Yeah, all people go to shops to finds job or to spend money.  
Me: So, you think money is the real world?  
Mila: Yes. |

Figure 35. Mia’s “Our everyday needs” photo for her first photo elicitation interview

Mila took this photo of a busy road with big screens showing commercial ads made on a computer. Mila believes that the real world is about people needing to earn and spend money. The real world is about making money to spend it on buying things to address their needs. Mila here also saw the real world consciously, or maybe she was experiencing financial issues at the time of the study.

Sophia is in Year 7. She is from Pakistan and she was placed in the low attainment level group. She agreed that science is boring and that she does not want to do science in future. Her spoken English was good; she only answered this question.

| Sophia: Because we can’t live without water and the environment and the trees and the plants and some animals.  
Me: Because we can’t live without the water?  
Sophia: Yes. I chose it because it is very important, because the trees... we couldn’t have the trees and they produce the oxygen. The water makes the trees grow and if we didn’t have trees, people [wouldn’t] have a fuel fossil [sic]. |

Figure 36. Sophia’s “Our everyday needs” photo for her first photo elicitation interview
This photo shows a cup full of water. Sophia felt that this is the real world because we all need water and cannot live without it. I asked her to explain why, and she went on to talk about the importance of water generally, like how trees need water to live and to produce oxygen. Sophia mentioned that trees need water to grow as well. She did not mention why water is important for people in terms of growing up, for instance. Then Sophia jumped to a completely new idea, which is how people need fossil fuels, without explaining why.

Sophia claimed that everything needs water to live. There is a strong possibility that Sophia was thinking about the famous quote from the Holy Quran: ‘we made from water, every living thing’. You can find this quotation in almost every mosque in washroom area as a reminder to be mindful while using the water, as Muslims must perform wudu before each prayer. Wudu is the Islamic procedure for washing parts of the body, a type of ritual purification or ablution. Wudu involves washing the hands, mouth, nostrils, arms, head and feet with water and is an important part of ritual purity in Islam.

Maryam is in Year 7 and she is from Bangladesh. She was placed in the high attainment level group. She said that she believes science is not boring, but she does not aspire to pursue science in the future, and she was strongly opposed to taking more science in school.

Maryam: Because the real world includes houses, this is part of our lives, so and it has nature in it and we live in it like your real world.
Me: So what is the real world in this photo?
Maryam: The real world is where you live, your environment; so like houses.
Faiza is in Year 9. She is from Pakistan and was placed in the high attainment level group. Aliza agreed that science is boring and was strongly opposed to doing any science in the future. Her survey data shows that she is not interested in science.

Faiza: Because the real world [is] like houses and trees and [the] sky, so like nature, basically. Like the houses, the trees, the sky; that is perfectly the real world.
Me: Does that include people?
Faiza: Yeah, like people in the houses and the houses also on the earth.
Me: So, the earth is like the real world?
Faiza: Yeah.
Me: What about the sky?
Faiza: Like the clouds and like the clouds in the world, and the sun is out.

Maryam and Faiza’s photos are quite similar. They both show houses from outside with the sky and trees. They are from different classes, but they both see the real world as having a house to live in surrounded by nature and under the sky. Faiza’s picture has houses, trees and the sky. This was the real world to her. Living in a house is the real world. Faiza thinks that the combination of houses, trees and the sky are nature. None of these participants said that nature is the real world.

Maryam: ‘Because the real world includes the sky [and] houses, this is part of our life and, so, has nature in it and we live in it like your real world’.

Faiza: ‘Because the real world [is] like houses to live and trees and [the] sky, so like nature, basically. The houses, the trees, the sky; that is perfectly the real world’.

Both of the participants are from different age groups and attainment levels, which, as a result, indicates the likelihood that their understandings of what the real world as viewed through the theory lens comes from the cultural model.

Summary

The views of these participants are far from the views of the previous group, even if we found them originally different from one another. Each perspective is like a starting point for a new vision and new exploration. All of these images and views were kind of based on a similar
idea; they discussed and cited humans’ everyday needs, the importance of the environment, everyday struggles or things that are valuable to the participants themselves. It was tricky to determine the themes when analysing the data for the first time. I determined a theme for each picture, then found the shared views. Taken as a whole, the data show that this group shares an understanding of the real world. When we analyse the photos without looking at the interviews, we would have no clue what the meaning of each photo was.

**The third theme is**: the real world is plain

The third theme is **plain**, in that the participants think the real world is plain. This is what plain looks like from Emma’s perspective:

<table>
<thead>
<tr>
<th><strong>Emma</strong> is in <strong>Y8</strong> and she is from Bangladesh. She was placed in the high attainment level group. Emma loves science and strongly disagreed that science is boring. She enjoys science and wants to do science in future.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emma</strong>: I took this one. I think there is nothing disconnected from science; science shows us all about the world, the world that we are living [in], how everything works. So, without science everything [is] going to be plain. By plain I also mean this plain, like [it] is going to be nothing at all. I don’t think there is anything disconnected from science because, like, everything that we used, we see something [is] somehow going to be related to science.</td>
</tr>
</tbody>
</table>

![Figure 39.Emma’s “the real world is plain” photo for her first photo elicitation interview.](image)

‘**The real world is plain**’: this is the sentence Emma started with. I was shocked, as Emma was fully confident and certain about this answer. She got nervous when I asked her to explain it more to me; she said ‘**Miss, it is nothing**’. Emma said she believes that the real world is plain; I tried to understand and find out why the real world is plain. She said ‘**the real world is plain, there is nothing, there is no invention, there is no technology, it is only like [a] plain world**’. Emma’s point of view could come from the importance of science, as she said if there were no inventions, there would be no technology, so she might think the real world started after science. It was one of the strangest answers I received, and I will discuss Emma’s full case later.
The fourth theme: the real world is relationships with family and friends

Ayah is 15 years old. She is in Year 9 and was placed in the middle attainment level group in science classes. She is from Pakistan. The language spoken in her home is Urdu. Ayah disagreed that science is boring, however she does not want to be a science teacher.

| No Photo | Ayah: 'Because I don't personally see the world as all about money, but most people... like I remember once in the class, a teacher was asking us what job you want to do, and everyone was like the one with the most money [or] salary. I was like, there is so many other things more important than money, but still everyone wants money more than anything else'.
Me: So, if money is not the real world for you, what is the real world?
Ayah: [The] people that you meet around us, family, friends and other relationships. |

Ayah sees the real world as our relationships. She was relaxed and seemed like she had had this conversion before, which it turned out she had. She left this question at the end of the interview as it something she was pretty sure about. Ayah had discussed the meaning of the real world before with her friends, who were also involved in this study. She was annoyed about their viewpoint because they think the real world is about finding jobs and earning money. For Ayah, the real world is about relationships, in contrast to the second group, who thinks the real world is about meeting their needs.

The fifth theme is: the real world is reality (e.g. waking life, life circle).

The last theme is that the real world, as we call it, is reality; this is based on the participants’ views, which we are going to discuss. The theme involved two pictures, of a book and the sky. At first glance, these pictures look like they are not related, but the way that participants described their viewpoints made them seem connected.
Raneem is in Year 8. She from Pakistan and language spoken in her home is Dutch. Raneem was placed in the low attainment group. She had a very positive view toward science. She strongly disagreed that science is boring. However, she was also strongly opposed to becoming a scientist or science teacher in the future.

Me: How do you see the real world?
Raneem: Because in the real world, your life is like a book, so you have a beginning and a problem and the end.
Me: What kind of problems do we have?
Raneem: For example, some people might have been bullied, so they have to face that and try to grow up.
Me: What is the beginning of our life? And the end?
Raneem: When we are born and when we die.

Raneem, who took a picture of the book she was reading at the time, said she thinks the book represents the real world. She said that ‘because in the real world, your life is like a book, so you have a beginning and then you have a problem and then an end’. Raneem thinks the real world like a book because books have beginnings, stories to tell and endings. I assume that Raneem was talking about the life cycle, which is about the changes and developments in a person’s life. Raneem also talked about problems, by which she maybe meant the challenges and obstacles people face and overcome on a daily basis.

I asked Raneem about an example of those problems, she said ‘for example, like, some people, they might get bullied, so then you have to face that then, you know, you have to tell their teacher or something’. Raneem mentioned being bullied at school; maybe this is something she was struggling with herself. I think that this is one of the strengths of using the photo elicitation method, as it allows for listening to the students. It shows how an open question could lead to hidden stories and struggles.
Luna is in Year 8. She was placed in the low attainment level group. Luna is from Asia and the language she speaks at home is Urdu. She strongly agreed that science is boring and she did not see science lessons as exciting. Moreover, she was strongly opposed to pursuing any future path in science.

Me: How do you see the real world, Luna?
Luna: Because as you can see, you are in the real place; you are not dreaming or something.
She points to the sky on the photo, so I asked the following question.
Me: You pointed to the sky; do you think the sky is the real world?
Luna: Yeah, it is for me. [It] shows me that I am alive.

Luna took the picture from her bedroom on the first floor of her house. I think she went to the second floor to get closer to the sky. Luna sees the real world as being represented by when you are wake and not dreaming. While talking, she pointed to the sky in the photo. Luna thinks that the real world is what you see in front of your eyes, when you are not sleeping or dreaming, but when you are fully awake. This response also falls under the theme of visibility, which we will discuss later on.

Reflection on the analysis of the responses to the first statement

Take a photo showing how you see the real world.

There are a few points that should be pointed out. First, the word ‘nature’ was the most repeated word when discussing the real world. While each participant had a different view or explanation, all of the responses in the first theme were about nature.

The second theme was about human needs, which, to the participants, means people’s everyday needs, such as the need for a floor to walk on or a car to drive, or the necessity of money to sustain a life. The real world, from this group’s perspective, was about living requirements.

The third theme is ‘the real world is plain’. I struggled to interpret this response. I was thinking of including this photo with the first theme, which was nature, but during the PEI setting, I found out that the participants did not see the real world as nature but as plain.

The fourth and fifth themes are kind of related to the ways of feeling, thinking or consciously experiencing life. The fourth theme is that relationships are the real world; the participants view
the real world from a social and emotional perspective, so she did not include any photo and, instead, preferred to talk about it. The fifth theme I chose to call ‘reality’, because both participants talked about something related to sense and which could be recognized by our eyes, and about being conscious and not dreaming. The real world could be the virtual world or the imagined world.

The data from the first statement shows how the participants' perceptions of the real world are varied. Sometimes the pictures are similar in terms of photography. However, the participants' expressions and the explanations of their views on the photos was entirely different. The data shows how often there are frequent, shared opinions and unspoken interpretations. The term ‘the real world’ indicates that different cultural models are shared between young people. There are common as well as distinctive understandings of the real world.

5.2.2. The second photo statement

**Take a photo from anywhere showing the connection between science and the real world.**

After the participants defined the real world, as per the first request, we then sought to see how they would connect their views of the real world with science. Some of the participants applied the same view of the real world for the rest of the task, while others dealt with each task separately. They used new or different views of the real world, depending on the request.

In the beginning, I was worried about why they kept changing their view of the real world; did they understand the task? Then, my supervisor reminded me of the primary purpose of the study; it is about exploring young peoples’ perspectives, not about young peoples’ ability to think sequentially.

Seven themes emerged from the discussion of the relationship between science and the real world, which will be presented with a reflection on each theme:

- Cars.
- Electricity.
- The process of growing.
- Light and sun.
- The role of trees.
- Everything is connected.
- Exploring space.
2.1. The first theme is **cars**

The participants came with the same title for the following photos, but with different point views and explanations. Both photos include a car, trees and houses. The example used in both to show how the real world is connected to science is cars.

![Participant’s set of two photos for the first theme of the relationship between science and the real world.](image)

**Maryam** is in **Year 7** and she is from Bangladesh. She was placed in the high attainment level group. She said that she believes that science is not boring, but she does not aspire to pursue science in the future. Maryam was strongly opposed to doing any more science in school.

![Maryam’s “cars” photo for her second photo elicitation interview.](image)

**Maryam:** I want to start with this one... the real world, to me, is more, like, about nature and more about natural stuff, and having a car is part of everyday life, so you drive it... [it] is like an invention, so [it] is part of science. Together [it] is like my real world with science in it.  
**Me:** So, in this photo, the science is the car and what is the real world?  
**Maryam:** The trees and outside.

For Maryam, the real world remained the same from her first statement; she still sees the real world as what we use and need in our everyday lives, so the car was an example of science in her real world, as something that meets everyday necessities.  

Maryam said: *The real world to me is more like about nature and more about natural stuff, and having a car is part of everyday life, so you drive it, [it] is like an innovation, so [it] is*
part of science. Together [it] is like my real world with science in it’. She sees science as connected to the real world through innovations like cars. The car was Maryam’s example of an invention and part of science. It worth noting that the students had studied cars and movement in science class.

Tina is in Year 8. She was placed in the low attainment level group. She is from a black background. Tina was friendly and smiled all the time. She was a little upset about the fact that she was placed in the low attainment level group. Tina wants to be a lawyer and she strongly disagreed that science is boring.

The example for science in the real world was the car, because cars are made by science. Tina thinks cars are related to science because ‘cars and things, they [are] all linked into science because they [are] all made by science’. Tina does not mention the houses or the roads in the photo. Clearly, Tina has information about cars’ functions and movement, which comes from her science lesson as she said, but it was not complete information: ‘science tells me that cars [are] faster and forces and things, this is something I learned in science as well’.

Reflection:
Maryam and Tina are both in Year 8, but they are from different attainment levels and were taught science by different teachers as well. They both gave the same example but with different interpretations. They related cars to science, but with Maryam it was as an invention from science that is used in everyday life; she does not talk about any scientific facts or any
vocabulary, as Tina did. Tina believes that cars are made by science and she is studying cars in her science lessons right now. Tina tried to explain how cars work and used some scientific vocabulary based on her understanding. Both participants were studying the unit on motion and cars during the time of the study. However, Maryam seems to see cars as scientific inventions and an example of the connection between science and her real world. While Tina was trying to explain how cars work and what might be involved in that, she tried to remember what she had been studying in her science lessons.

**The second theme: electricity is the key**
The second theme is electricity. Ameerah and Reem both used electricity as an example of the connection between the real world and science.

![Image](image_url)

*Figure 46. Participant’s set of two photos for the second theme of the relationship between science and the real world.*

**Ameerah** is from **Year 8** and was placed in the low attainment level group. She is from the Middle East and speaks Arabic at home. She speaks and writes in English very well; however, she faced some difficulties in trying to explain herself in detail in English. Ameerah strongly disagreed that science is boring. She aspires to become a dentist in the future.

![Image](image_url)

*Figure 47. Ameerah’s “electricity is the key” photo for her second photo elicitation interview*

**Ameerah:** ‘The electricity becomes like science, for example, like when used electricity [is used] for cars, homes and like other countries. And the green trees, they give you paper and, for science, recycle for science. So, I thought that trees could be [used] for science and for the real world as well, when they gave a paper, you recycle the paper with the right bins’.
Ameerah’s photo is from the train station near her house. She sees the electrical wire from the train station as representative of science because they are outside and between the blue and the green (the trees and sky). Ameerah adds the trees to be presenting science as well in this statement, she draws everything she can from the photo, into science – making it as comprehensive as possible. She considers trees to be science as they give us papers for recycling, I found it interesting that she talked about recycling although they do not have any dedicated lessons or units for this topic.

According to Ameerah science they studied recycling one time and it was a small part of the lesson. The teacher was shocked that she remembers it and mention it to me as Ameerah has been known as a student who is always forgetting and hesitating of presenting an idea.

Reem is in Year 7 and she is from Syria. Reem recently moved to England. She refused to speak in Arabic, although her English is minimal. I think she refused to speak in Arabic because we had other participants with us, and she wanted to show her that she can speak English. According to the science teacher, Reem is a very competitive person.

Reem: ‘I chose the phone because of the electricity. You see the electricity is important, and without science, we can’t think about the electricity. Society helps for the electricity, like showing what is the electricity’.

For Reem, electricity represents the relationship between the real world and science. The phone was an example of electricity. Reem stated that science is fundamental, and without science, we would have never created electricity. Reem seems to value science and the importance of science. Reem showed the phone as an example of how vital electricity is to us. It can be also seen to show how the electricity is meeting people’s needs as well. I could not get more details from Reem because she was nervous; the tension came from the language barrier; you can notice from the broken sentences. However, I remained silent and kept listening to her talk.
The third theme: the process of growth

The third theme is the process of growth; five participants considered the growth of plants as representative of science.

Figure 49. Participant’s set of five photos for the third theme of the relationship between science and the real world.
**Faiza** is in **Year 9**. She is from Pakistan and was placed in the high attainment level group. She agreed that science is boring and was strongly opposed to doing any science in the future. Her survey data shows that she is not interested in science.

Faiza: It is still like the real world but [has] got more nature like plants and stuff like that.

**Me:** What is ‘science’ in this photo?

**Faiza:** [The] plants, because they grow. You can see the light here, like they [are] grown with photosynthesis.

**Me:** And this make them science?

**Faiza:** Yea, because in science we learn about plants and stuff like that.

**Me:** And what [is] the real world in this photo?

**Faiza:** Just like [the] nature.

Faiza’s ‘real world’ included nature, houses and the sky. Her example of the real world as it connects to science was the growing plants. Faiza clearly thought of plants as science because she learnt about them in her science lessons. I guess she meant by saying the light is the sun. It seems she knows that the plants grow by photosynthesis, but she does not know how the process actually occurs.

**Raneem** is in **Year 8**. She is from Pakistan and the language spoken in her home is Dutch. Raneem was placed in the low attainment group. She has a very positive view towards science. She strongly disagreed that science is boring. However, she was also strongly opposed to becoming a scientist or science teacher in the future.

Raneem: Plants: plants live, and they have cells. The [lives are] similar to ours.

**Me:** What is science in the plants?

**Raneem:** Animals; they eat these plants which contain sugar in them, and then give [the] energy to the animals. So, this sounds to me [like] science.

**Me:** What is science in the plants?

**Raneem:** First, they are like seeds and when you put water [in], [it] starts to grow, so as [it] grows, more features come, like, for example, that [it’s] meant be a flower. So first, it [is] all planted and as [it] grows, [it] grows leaves and then grows a flower.
According to Raneem, the plants are like us, as they have life and cells. She stopped explaining, which forced me to ask what science meant to her, and then she started talking about how animals obtain energy from eating these plants because of the sugar in it. However, I would relate this view to her view about the real world, which was the cycle of life. It looks like she is representing part of the cycle of life, but in a scientific way, and you can see this when she was explaining the life cycle of plants and flowers as seeds and how, by watering them, they grow up and become what they are meant to be. Raneem seemed to have a lot of unorganised or incomplete information about science. She wanted to share her opinions, however she jumped from one point of information to another.

Ayah is 15 years old. She is in Year 9 and was placed in the middle attainment level group for science classes. She is from Pakistan and speaks Urdu at home. Ayah disagreed that science is boring, however she does not want to be a science teacher.

Ayah: Because basically, in science, we studied the photosynthesis and things to do with plants and how plants to inspire by human inspire [and] how [it] is related to the real world, I think.

Me: So, the science in this photo [is] what happened?

Ayah: Yes.

Me: And the real world?

Ayah: Like the plants are in the real world, and that inspired [me] to do science and [is] inspired by photosynthesis.

Me: So that photosynthesis is science?

Ayah: Yeah.

Ayah took a closer photo of plants to show an example of the real world with science in it. However, she does not mean the plants themselves, but rather photosynthesis. Ayah justified her thinking in terms of choosing photosynthesis because this is what she had been studying in her science lessons. She does not explain the process of photosynthesis. She said: ‘photosynthesis, because basically in science we studied the photosynthesis and things to do with plants’. It was like a fact that she did not even need to explain, so we moved on to the following prompt.

Figure 52. Ayah’s “the process of growth” photo for her second photo elicitation interview
**Mila** is in **Year 9**. She is white British, and she was placed in the high attainment level group. Mila strongly agreed that science is boring, and she was strongly opposed to doing anything related to science in the future.

Mila: Plants because photosynthesis and other things. The plants and nature is the actual world and the ground is made by science.

Me: What is the science in this picture?

Mila: I think the real world is the plants that in science that’s involve with plants.

Me: What is the science in the plants?

Mila: [It] is like photosynthesis, living, plants living and organs.

Mila also sees that plants are the real world and [that] the ground [is] made by science and the ‘actual’ world is nature. The ‘actual’ world is plants and it’s involved with science because of the photosynthesis. The process of growth is science and this opinion is related to what they have been studying. Mila has the same view as Ayah; they both mentioned that they studied photosynthesis in science class without any further explanation of the process itself.
Luna is in Year 8. She was placed in the low attainment level group. Luna is from Asia and she speaks Urdu at home. She strongly agreed that science is boring and that she does not see science lessons as exciting. Moreover, she was strongly opposed to doing any science in the future.

Luna: Science is flowers and flowers [are] related to science, and flowers [are] also in the real world.
Me: What makes flowers related to science?
Luna: Like, photosynthesis.
Me: The ground is the real world?
Luna: I took a picture of that because, in the real world, there are plants and this [is] a growing plant. This plant is related to science, but plants [are] not in science, they are in the real world; they live in the real world.

Luna has a language barrier; she was a bit stressed. Luna’s example of the real world is connected to science by the flowers. Luna thinks the flowers are science and they are related to science by photosynthesis, and they are in the real world. She seems to look at science and the real world as containers which contain each other, so as a result, they are connected. Luna sees plants as the real world; they are not science. However, what is going on inside the plants in terms of growth is science. I assume what represents science for Luna is what she studies in school.

The fourth theme is: light and the sun
Two participants used lights as an example of science in the real world. However, their understandings were not the same.
**Bella** is in **Year 7**. She is Somali and was placed in the low attainment level group. She speaks English as second language. Bella agreed that science is boring.

<table>
<thead>
<tr>
<th>Bella: The lights, because [they are] like the sun from the outside, as the same as this [she pointed to the photo]. They are both giving [off] light. The sun is from the real world and the light [is] from science.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 56. Bella’s “light and the sun” photo for her second photo elicitation interview</td>
</tr>
</tbody>
</table>

Bella compared the sun from outside to the light inside as they both do the same job; they give off lights. For Bella, the sun is the real world and light comes from science. I was amazed by the way she made that connection. The connection is that the sun (from the real world) and light (from science) do the same job. I was surprised by Bella’s example, so I asked her science teacher if she mentioned this example in the classroom; the science teacher was surprised as well and did not expect Bella to come up with this idea, as Bella is quiet most of the time during science lessons and she is in the low attainment level group.

**Olivia** is in **Year 7** and was in the low attainment level group. She is from Pakistan and speaks English as a second language. She thinks that science is boring. She was relaxed and confident, which made me ask questions, but I think the language barrier was the obstacle.

| Olivia: This one, I like. [It] shows, like, nature within science, because [it] has light. The trees represent nature.  
Me: What makes the light science?  
Olivia: Because the technology in it, like bulbs, has something to do with science, like the wires and everything, but the sun obviously has no wire, so [is] that the nature.  
Me: Why did you say the light is science?  
Olivia: Because they have the wires and how they have the electricity, but the sun does not have electricity, just the sun and big stars. |
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Figure 57. Olivia’s “light and the sun” photo for her second photo elicitation interview</td>
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</table>
Olivia’s photo is not clear. It was taken from the car to show the natural light from the sun with the trees and the lights on the road. The sun and the trees represent the real world. The reason for choosing the sun is because it creates light without the use of technology, in contrast to the lights on the road, which need wires and electricity to give light. Technology for Olivia is wires and bulbs, which emits the light, so they belong to science. Olivia compared the sun’s light to the lights of the road in terms of the job they are doing, which is giving light.

**Reflection**

Bella and Olivia have the same idea: that light is an example of what connects science to the real world. However, their interpretations were different. Bella did not go deep or think any further when she chose to talk about light. Bella thinks the sun and indoor lighting do the same job. Bell did not mention how indoor lighting is connected to science. The sun is from the real world, and indoor lighting is science, and they are connected because they do the same job. Bella did not talk about electricity’s role in this matter or why the room light is science. Is it because it gives us the light inside the houses, not the sun, or because of the electricity? However, she might think that having lights everywhere, inside and outside, is essential. Olivia brought up the same idea about connecting science to the real world. Olivia made the same comparison, but with further justifications. She said that thinks that the sun gives light, and that it is from the real world, whereas the streetlights also give light, but it is from science. The reason that the streetlights are science is because of the wires and technology. Both Bella and Olivia seemed to understand that the term ‘connection’ can denote two things that do the same job.

**The fifth theme is: the importance of trees**

This group sees the real world with science in it represented in the role of trees, as trees are a source for oxygen. This group had language barrier issues; I could not interrupt them to obtain more details.

![Participant’s set of two photos for the fifth theme of the relationship between science and the real world](image)
Eva is in Year 7 and was placed in the low attainment level group. She is from Bangladesh. She speaks English as a second language. She spoke broken English. I chose her because Eva strongly agreed that science is boring and that she did not enjoy science lessons.

![Eva's photo](image1)

**Eva:** Science is like nature; in science, we learned about oxygen and water, [and how] everything is related to science. People cut down some trees, and birds will lose [their] habitat and also [it is] good for us [as] we get paper and books, and if we decide not to cut the trees, [it] is for our disadvantage, [as] we [are] not going to get paper and books.

Eva took a picture showing the sky and trees as an example of the connection between science and the real world. For Eva, nature is science and the real world. Because Eva learnt about oxygen and water in science lessons, and because the trees exist in nature, they are related to science as well. Eva also talked about an environmental issue, which is cutting down trees. She was against this because she was worried about the birds losing their ‘habitat’. At the same time, she agreed with cutting down trees to produce papers. Eva seemed confused about where to stand on cutting trees; she was talking and thinking at the same time and I did not interrupt. Again, there are a lot of questions and misconceptions for young people when such issues arise. While talking, Eva realized that we need to cut down trees to get paper. She was confused and decided to move on to the next photo statement without waiting for my comments or opinion.

Sophia is in Year 7. She is from Pakistan and she was placed in the low attainment level group. She agreed that science is boring and that she does not want to do science in the future. Her spoken English was good, but she only answered this question.

![Sophia's photo](image2)

**Sophia:** The trees [represent] science because I think science [is] all about living, and because if we didn’t have trees, that is a living thing, if we didn’t have trees we wouldn’t be living.

**Sophia:** that give us oxygen and sometime is grows the food.
Sophia took a picture of a tree to represent the science. For Sophia, the trees are an example of how the real world is connected to science. According to Sophia, science is all about living things, and the trees are necessary for living. The trees give us oxygen and food. The trees are the real world and what the trees do is science. Sophia seems to value the trees because trees give us the food and the oxygen for life. On the next page the sixth theme.

**The sixth theme: everything is connected**

<table>
<thead>
<tr>
<th>Emma</th>
<th>Year 8 and she is from Bangladesh. She was placed in the high attainment level group. Emma loves science and strongly disagreed that science is boring. She enjoys science and she want to do science in future.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emma:</strong></td>
<td><em>I think this photo [is] showing the connection between science and the real world because there are many things related to science and most of them in the modern world, and that because in [the] modern world, science has changed everything; for example before, things we discovered [were] nothing, like cars, houses, plants. There [were] plants, but they were not discovered; they [were] discovered later and learned about in more details... another thing that science has discovered [is] how everything in everyday things work and how we can use [them]. Also, without science, that would be nothing. I took this picture because it is mainly showing... because before, science discovered in depth, there was not many things, for example houses, cars, like everyday things that we used. But science has changed everything by making new stuff, functions and technology. I think science did that because it is related to science a lot, that [is] how we used everyday things. That is [the] way I thought this picture shows mostly the connection between science and the real world.</em></td>
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Plain is the title of the above photo by Emma. Emma took a picture of the plain wall to describe the word ‘plain’. She believes that everything is related to science. She called these days the ‘modern world’. The modern world included cars, houses and plants. Emma stated that there
were plants before science, but they were not being discovered, so as long as they were not discovered by science, they did not count. Emma believed that science helped us to discover the world’s plants and learn about them in detail and that these discoveries are part of the real world. As well, science is also about inventing new stuff and learning about the purpose of this stuff. So, for Emma, science is about discovering, inventing and having the right information about everything.

The seventh theme is: **exploring space**

**Layla** is in **Y9**. She is Pakistani and she was placed in the high attainment level group. She strongly disagreed that science is boring, even though she doesn’t read anything related to science outside of school and she does not want to be a science teacher herself.

Layla took a photo of the full moon and the sky at night. She thinks the sky and the moon are connected to the real world. Layla claims that the sky and the moon remind us of space. She did not explain how she really sees the connection; she was speaking slowly and thinking at the same time. The idea seemed to exist in her mind, and she tried to articulate it. However, the full moon is the real world and is connected to science. She does not explain how that connection is made. I assume it is because they used to study space in science lessons, so this is how she came to believe that the moon represents the connection between the real world and science.

*Figure 62.* Layla’s “exploring the space” photo for her second photo elicitation interview
5.2.3. The third photo statement

**Take a photo from anywhere showing the disconnect between science and the real world**

The response to this statement was surprising in terms of discovering how young people see the disconnect between science and the real world, which was fascinating. It was the most interesting statement.

The themes that emerged from this request are:

1- Visibility.
2- The sky.
3- Thinking.
4- Everything is connected.
5- Human-made.
6- Aliens.
7- A bag full of books.

### 3.1 The first theme: visibility

We named the first theme ‘visibility’ because the participants think the connection should be physical and they have to be able to define it by how they see it with their eyes. Therefore, the examples are inspired from the idea that if they cannot see it with their eyes, it is not connected.

![Figure 63. Participant’s set of three photos for the first theme of the disconnection between science and the real world.](image)
**Ameerah** is in **Year 8** and has been placed in the low attainment level group. She is from the Middle East; the language spoken at home is Arabic. She speaks and writes in English very well, however, she faced some difficulties in explaining her thoughts in detail in English. Ameerah strongly disagreed that science is boring. She aspires to become a dentist in the future.

![Figure 64. Ameerah’s “visibility” photo for her third photo elicitation interview.](image)

**Ameerah:** This is [a] food label, because food labels [are] not really related to the earth. [A] food label is like... food has a label talking about fat and weight and information. That is what I think; they are not together, they are different. [A] food label is from science, but we [have] disconnected them because [a] food label is different from the real world. The real world talks about humans, rivers, animals, trees, air. But this one [is] just like food.

Ameerah took a picture of the food label to show how science is disconnected from the real world. Ameerah’s real world is the Earth, and from Ameerah’s perspective, the food label does not belong to the Earth. The reason she distinguished the food label from the Earth is because the food label is just data about nutrition. Ameerah believed that the real world involves talking about humans, rivers, animals, trees, air, etc., whereas a food label shows only scientific facts.

**Ayah** is **15** years old. She is in **Year 9** and she was placed with the middle attainment level group for science classes. She is from Pakistan and the language she speaks at home is Urdu. Ayah disagreed that science is boring, however she does not want to be a science teacher.

![Figure 65. Ayah’s “visibility” photo for her third photo elicitation interview.](image)

**Ayah:** I tried to take photo of the metal thing, because right now in science we are learning what [are] metals and not metals, so that’s why I took a picture of this to show the metal. In science we only learned about [the] properties [and] products of the metal, but we don’t actually see it in real life.
Ayah took a picture of the building’s lift key as an example of science not being connected to the real world. She claimed that she had studied metal in science classes, but she never sees it in the real world, so as a result, metals are just science. Apparently, the real world is what she can see, so the lift is in the real world because she able to see it. However, metal is only information in science book; she is not able where the metal came from and how it becomes a lift keyhole.

3.2. The second theme: the sky

The second group chose the sky as an example of how the real world is disconnected from science, because the sky is not reachable and not changeable, as science is all about changing and discovering.

Maryam is in Year 7 and she is from Bangladesh. She was placed in the high attainment level group. She said she believes science is not boring, but she does not aspire to study science in the future, and she is strongly opposed to doing more science in school.

Maryam: The sky. What I meant is represent space and stuff. This is like the base of the world. It has nothing; [nothing] manmade in it and stuff. It is like part of the real world and space is part of the world. The world [exists] within space’.

Maryam took a picture from the window to show the sky. From Maryam’s perspective, the sky represents the base of the world, and the reason that the sky is not connected to science is because it has nothing ‘man-made’ in it. I assume the word ‘manmade’ here is a synonym for science, so science for Maryam is about making change and developing. The sky and space are examples of how the real world disconnected to science because it includes no manmade changes. Maryam does not give any example of what manmade mean. Also, she does not say science, so I assumed that science is the man-made.
Bella in Year 7 and she is Somali. She was placed in the low attainment level group. She speaks English as second language. Bella agreed that science is boring.

| No photo | Bella: I don't know. [Then she said] Oooh, the sky, because people can’t make the sky. |

Bella did not take a photo to address this statement. The moment I was about to move on to the following statement, she said ‘oooh the sky, because people can’t make the sky’. That is all that she said. I assume she meant the sky because it is not reachable, and no one can change the sky, a similar view to the previous participant.

3.3. Third theme: the way of thinking

The third group believes that we are both connected and disconnect to science based on the ways we think and the education we received.

Tina is in Year 8. She has been placed in a low attainment level group. She is black. Tina was friendly and smiled all the time. She was a little upset about the fact she was placed in the low attainment level group. Tina wants to be a lawyer and she strongly disagreed that science is boring.

| No photo | Tina: I actually don't know how science could be disconnected from the real world. Science could be disconnected in a way sometimes what people thinks as well. I am not sure. I don’t think actually there is anything disconnected from science. Science is so involved with [the] world today. So, I really don’t think something [can be] disconnected to science. |

Tina’s perspective about how science is disconnected from the real world fit into two themes, which is the way of thinking and the following theme, which is ‘everything is connected’. I could not choose one theme for Tina; her answer encapsulated two different ideas.

At the beginning, Tina was not sure what to use as an example of the disconnect between science and the real world. It also seems she skipped the request without thinking about it, so she tried to find an answer during the interview.

She seemed to not be fully convinced that science could be disconnected from anything. Tina believes that people’s way of thinking and how humans perceive science is how science might
be disconnected from the real world. She followed up by noting that she believes that there is nothing that is disconnected from science and that science is involved and connected to everything these days.

Layla is in Year 9. She is Pakistani and she was placed in the high attainment level group. She strongly disagreed that science is boring, even though she doesn’t read anything related to science outside of school and does not want to be a science teacher herself.

Layla: When education doesn’t reach some people around the world, so education is just for certain people, so if they have the chance, they [are] going to do it, if they [are] not, they [are] not’.

For Layla, the real world is disconnected from science if people do not have access to education. So, in her view, as a result of not being able to study and learn science, you become disconnected. The lack of learning and studying science is an example of the disconnection between science and the real world. I am not sure if science for Layla here is science as a subject in school, or if she meant doing experiments and exploring the world outside of school. We were out of time, so I did not have the chance to ask further questions.

3.4. The fourth theme: everything is connected

The fourth group believe that science is related to everything and connected to everything, so they believe that nothing in science is disconnected from the real world.

Emma is from Year 8 and she is from Bangladesh. She was placed in the high attainment level group. Emma loves science and strongly disagreed that science is boring.

Emma: I took this one [because] I think [that] there is nothing [that is] disconnected from science. Without science, everything going to be plain. By plain, I also mean this plain, like [it] is going to be nothing at all. I don't think there is anything [that is] disconnected from science because, like, everything that we use, we see something, somehow, [it’s] going to be related to science.
Emma took a picture of a plain white wall to show the meaning of nothing. Emma was very convinced by the idea that science is everything. From Emma’s perspective, all science is related to everything and there is nothing disconnected from science. So, as a result, Emma refused the idea of a disconnect between science and the real world.

3.5. The fifth theme: ‘human-made’

| Luna is in Year 8. She was placed in the low attainment level group. Luna is from Asia and speaks Urdu at home. She strongly agreed that science is boring and that she does not see science lessons as exciting. Moreover, she is strongly opposed to pursuing any science path in the future. |
|———|
| Luna: This said disconnection between the science and the real world, because this is something human-made in the real world, not in science. |

Figure 68. Luna’s “human-made” photo for her third photo elicitation interview.

Luna took a picture of a swing at her house. The swing is an example of the disconnection between science and the real world from Luna’s perspective. From her perspective, the swing is human-made, so it is science. However, the swing exists in the real world, not in science. Maybe Luna means ‘in science’ as in science lessons or the science classroom.
Aria is in Year 7 and she was placed in the high attainment level group. She is from Poland and speaks English as a second language. She had no issues with speaking. She said that thinks that science is not boring and that she enjoys science very much.

Me: What in this photo is not connected to science?
Aria: Cars, and the houses a bit, because they are not part of science; they not made out of science. I don't think [it] belongs to science, because cars and houses are not really like science, they are not related to science, so it is not really connected to science.

Aria took a picture to show cars, houses and trees. From Aria’s point of view, the cars and the houses in this photo do not belong to science because they are not made out of science. I think that by ‘made out of science’, Aria meant that they are not created by science, or she thinks because they do not study anything related to the cars and the houses in science lessons, they are not connected to science. She was talking slowly while articulating the explanation; she was a little bit nervous when she felt she needed to explain more and I looked like I was waiting for more of an explanation.

3.6. The sixth theme: a bag full of books

Faiza is in Y9. She is from Pakistan and she was placed in the high attainment level group. Faiza agreed that science is boring and was strongly opposed to doing any science in the future. Her survey data shows that she is not interested in science.

Faiza: This is just like school; if you forget about [your] science book, you do not have science. It is just a book without science.
Me: So, you said if we don’t have a science book in it, that means it is disconnected from the real world?
Faiza: Yea.
Me: What is the real world?
Faiza: [It] is like in school and people.
Faiza was very confident and sure about her answer. She took a picture of her school bag as an example of the disconnect between science and the real world. Faiza thought that school and people are the real world here, and having a bag full of books is an example of how the real world is disconnected to science. Faiza said she believes that science is having a science book within your books or bag, if you forgot about it that means it does not exist. Apparently, science for Faiza is only a subject in school, so if she is not studying science, that means she is disconnected from science as she thinks people and school are the real world. As a result, she is the real world here.

3.7. The seventh theme: aliens

| Raneem | is in Year 8. She is from Pakistan and the language she speaks at home is Dutch. Raneem was placed in the low attainment group. She had a very positive view towards science. She strongly disagreed that science is boring. However, she said she was also strongly opposed to becoming a scientist or science teacher in the future. |
| No photo | Raneem: Aliens, because we do not know if they exist or not, so science is still finding out if they exist. Me: In which way are they disconnected from the real world? Raneem: Because we think about it. We like to make up this creature, but we don't know if it is real. |

Raneem did not take any photo for this statement. She wrote in the paper the title ‘aliens’ next to the photo statement request. Raneem thinks aliens are an example of the disconnect between science and the real world. She said she assumes that the search for aliens represent science. They are disconnected from the real world because no evidence that aliens exist has been discovered yet, so they are part of the imaginary world.

5.2.4. The fourth photo statement

Take a photo in your home of somewhere or something that shows a connection between science and the real world.

We asked the participants to take a photo at home to represent the relationship between science and the real world. We emphasised that they should not take a photo of anything without their parents’ permission, specifically faces. Six out of 16 participants skipped this request. Some of
them said they did not know what to photograph, while others just moved on to the next request without any explanation and I did not ask.

Three themes emerged from this task. I will present them below in order of their popularity.

1- Nature and plants.
2- Chemical things.
3- Science lessons.

4.1. The first theme: nature and plants

This group took pictures of their gardens to show how science is connected to the real world from home. The shared idea in this group was that garden plants represent the real world and science; the real world, because nature is the real world and the growth process of the plants is science, so the garden represents the connection between science and the real world at home.

Ameerah is in Year 8 and was placed in the low attainment level group. She is from the Middle East; the language spoken at home is Arabic. She speaks and writes in English very well, however she faced some difficulties in explaining herself in detail in English. Ameerah strongly disagreed that science is boring. She aspires to become a dentist in the future.

Ameerah: I took this picture because the leaves that have grown up are nice and beautiful and could be connected by science and the real world be like the real-world, blue and green, and science could be sun plants, recycling and could be, like, about who [grew] them or something, like the food. Science could be connected by the food, like with the real world as well. ‘Can we connect like that?’ she asked me.

Ameerah took a picture of her neighbour’s garden as an example of the connection between science and the real world at home. Ameerah tried to show different types of plants in the picture, as she was so impressed by them. Then, she talked about a ‘sun plant’, by which I guess she meant photosynthesis. Ameerah said she thinks the plants are connected to science
through photosynthesis, recycling and growing food. However, she was not sure about this connection.

### 4.2. The second theme: chemical things

This group saw science and the real world at home in cleaning products, either for clothes or for humans, like hand sanitiser.

![Participant’s set of three photos for the second theme 'chemical things’](image)

**Bella** is in **Year 7** and she is Somali. She was placed in the low attainment level group. She speaks English as second language. Bella agreed that science is boring.

**Bella**: This one, because people use it as well, and you need, like, that, do you know the water, and that is connected to science because [it has] all that acid, I know that, and people also use it.

![Bella's “chemical things” photo for her third photo elicitation interview](image)
Bella took a picture of hand sanitiser to show science at home. She said she believes that hand sanitiser is related to science because it contains acid. Plus, the hand sanitiser is related to the real world because people use it to clean their hands and it works as substituted for water in the real world. I am not sure where the idea that hand sanitiser contains acid came from. I do not think it was from science lessons.

Faiza is in Year 9 and she is from Pakistan. She was placed in the high attainment level group. Faiza agreed that science is boring and she was strongly opposed to doing any science in the future. Her survey data shows that she is not interested in science.

Figure 74. Faiza's “chemical things” photo for her third photo elicitation interview

Faiza: Because [it has] like a lot of chemicals in it, so it is like science. So, it’s got chemicals, and in the real world because we use it to clean clothes and stuff.

Faiza took a picture of laundry detergent to show science at home. She thinks laundry detergent is science because it has a lot of chemicals in it. However, she did not define what the chemical are, like the previous participant did. The detergent is related to the real world because people need it and use it to clean their clothes, so the laundry detergent comes from science and we use it to meet our needs in order to clean our clothes in the real world, and it represents science at home.
Layla is in Year 9. She is Pakistani and she was placed in the high attainment level group. She strongly disagreed that science is boring, even though she doesn’t read anything related to science outside of school and she does not want to be a science teacher.

A chemistry notebook was Layla’s example of science and the real world at home. She said that she thinks that studying chemistry increases people’s curiosity and encourages them to know more about science and chemistry. Maybe Layla thinks science is chemistry, as she did not mention any other field in science. Maybe that is because chemistry is just present at the school, whereas biology and physics are more likely to be found outside the school. Layla is keen to know how chemistry started and was introduced to human beings. She seemed curious to know more about how chemistry was introduced to the world from the beginning.

4.3. The third theme: science lessons/science at school

This last group saw science as science in school, and the examples were all based on science in school.
Mila is in Year 9. She is white British and was placed in the high attainment level group. Mila strongly agreed that science is boring, and she was strongly opposed to doing anything related to science in the future.

Figure 77. Mila's “science lessons/science at school” photo for her third photo elicitation interview

Mila: I took a picture of my cousin, because I think about genes showing the connection between science and the real world because the real world [is] actually about people, because science made people, like the x and y chromosomes and genes that your body [has] and all the blood and the heart. So, this is showing the connection between the science and the real world from home.

Mila took a photo of her cousin as an example of science in the real world at home. Her cousin represents science from a biological aspect. At the time of the study, the Year 9s were studying genes in science class. Mila adapted what she had learnt in the science classroom to address this request. She connected what she had been studying in science class at school to home. Mila said she believes that the real world is people, and science is about the details in the human body, like the genes and the blood, etc. Therefore, her relative from home is an example of the connection between science and the real world.
Raneem is in Year 8. She from Pakistan and speaks Dutch at home. Raneem was placed in the low attainment group. She had a very positive view towards science. She strongly disagreed that science is boring. However, she was also strongly opposed to becoming a scientist or science teacher in the future.

Raneem: So, when you spin it, [it’s] like physics in it. So, when it is spinning, you can see it is turned around because of the gravity and like, in the future, this can be more developed.

Figure 78. Raneem’s “science lessons/science at school” photo for her third photo elicitation interview

Raneem’s example was a spinner. She took a picture of a spinner she owns at home to represent science. The spinner was an example meant to represent science. Raneem tried to explain how the spinner works to prove her point; she mentioned physics and gravity. She talked about how technology is going to be improved and developed in future. Raneem did not explain much, however she seemed to have some scientific vocabulary to share. I asked Raneem’s science teacher if they discussed spinners in the classroom and she was shocked. She told me that she gave the spinner out as a gift to the student who did well on the last test, but she never talked about it. Maybe Raneem was curious about the spinner so she looked up information about it.

5.2.5. Summary
The section presented the thematic visual analysis. The study has four photo statements exploring young people’s perspectives regarding the connections and disconnections between science and the real world. We presented and discussed the themes generated from each statement. Some themes were popular and repeated across different ages and attainment levels, whereas other themes occurred only once, with fascinating interpretations. There are more ways of interpreting science by young people, shared without spoken words, than we think. The photo elicitation interviews uncovered and unpacked a lot of the perspectives that both the students and science educators take for granted. The data also shows that there are many misconceptions about science and incomplete ideas about what science is. There are clearly many shared ideas regarding science, which we refer to in term of the theory of cultural models.
There are many cultural models about the ways young people perceive the connections and disconnections between science and the real world.
CHAPTER 6
Discussion

This chapter discusses the findings of this study within the context of the current theoretical and empirical literature. The primary purpose is to address the research objective: to explore secondary school student perspectives of science education in the real world based on a selected photo through using photo-elicitation methods. Given the exploratory and more participant-driven approach used, however, the results do provide insight into how young people see science in the real world from their perspective.

The framework used throughout the following discussion of how young people see the relationship between science and the real world is derived from two sources, the first of which is the cultural model theory. In brief, the cultural model is tacit, unconscious and takes for granted the sharing of knowledge within society (Hamilton, 1996). The second source is the border crossing theory; this theory is about the unspoken struggle and challenge that young people face in order to cope with science by crossing cultural borders.

The research questions are:

1. How do secondary school students describe their understanding of the real world?
2. How do students make meaning of their experiences to describe how science is connected to and disconnected from the real world?

To discuss the results, we will present each research question in the table next to the photo request we gave to the participants.

6.1. The real world from young people perspective

<table>
<thead>
<tr>
<th>The first research question is:</th>
<th>How do secondary school students describe their experiences in seeking the real world out of school?</th>
</tr>
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<tbody>
<tr>
<td>The photo request is:</td>
<td>Take a photo from anywhere showing how you see the real world.</td>
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</table>
This request is aims to understand how young people see the real world. This is achieved by allowing young people to demonstrate their understanding in pictures and then talk about the reasons for their views about the chosen photos. As discussed in earlier chapters, PEI is a powerful tool that can be used to understand and contextualise school through the student’s eyes (Luttrell and Chalfen, 2010, Meo, 2010, Zenkov et al., 2011). The response to this request generated five themes (pg. 129). In the results chapter, we present the themes in order, starting from the most commonly-shared ideas to the least. Here, we focus on the most commonly-shared ideas to show the power and effectiveness of using the cultural model as a theoretical framework in exploring people’s perspectives.

The participants’ responses to this question were unexpected. The participants’ understandings and views on the ‘real world’ produced five different themes. Having multiple cultural models can be a great support for deep reflection and honest critique (Gee, 2004) as discussed in chapter 3. However, it is an undeniable fact that researchers, teachers and curriculum developers already presume to know how young people see the real world. Understanding the students’ views can help to strengthen the trust between students and teachers (Murphy and Torre, 2014), which, as a result, will have a positive impact on students’ relationships with their schools.

The participants shared five different themes to describe the real world. The data show that young people’s views are entirely different from my assumptions of how they would describe the real world. I thought that the real world would be simple and easy for them to express, and that it would not be confusing. In practice, I had many participants say: ‘Miss, this is hard. What is the real world? It is hard to answer this request’. I did not explain anything further, but I did keep reminding them that ‘there is no right or wrong answer. Answer it [in] the way that you understand it’. The data for the first research question generated five themes; the most repeated theme was that the real world is nature and natural resources. Notably, the participants who already chose nature to represent the real world were confident and sure about their answers, but they were not able to explain why nature represented the real world. From a theoretical lens, this shared idea was a cultural model which views the real world as nature.

The majority of participants reported that the real world is nature and natural resources. They gave examples like trees, animals and rivers. They tried to take photographs of nature from cars, buses, backyards and parks to prove that nature is the real world and that it is everywhere. In the light of the theoretical framework, we can consider nature as a cultural model of the meaning of the real world. It would be interesting to know how this idea was spread between young people. Knowing the shared idea or the cultural models within a group of young people
about the meaning or the interpretation of the real world is vital to strengthening young people’s relationship with science and it will help science educators pay attention to the fact that nature is a commonly shared idea about the meaning of the real world. Also, nature is essential, and we could use these views to find ways to connect nature to science more strongly. This simple question reveals a commonly shared idea that we could use to enhance the way that we teach science. Six of the sixteen participants, however, do not see nature as representative of the real world, so we cannot just take this finding as fact and use it to establish new teaching strategies. We need to explore the meaning of the real world further, in the sense of trying to connect young people’s real lives to science. Moreover, it is important to try to rebuild young people’s relationships with science and dismantle the stereotypes that science is only a subject at school, that it is hard or boring and that it is only for ‘nerdy’ people.

6.2. Connections between science and the real world

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<tr>
<th>The second research question is:</th>
<th>How do students make meaning to describe the relationship/connection between the real world and science?</th>
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<tr>
<td>The photo relating to the ‘connection’ side of this question was:</td>
<td>Take a photo from anywhere showing how you see the connection between the real world and science.</td>
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Understanding how young people see the connection between science and the real world is at heart of this research. The goal was to find out how young people articulate their understanding of the connection through the use of photo prompts by discussing the reasons behind their chosen pictures, which turned out to be very interesting and eye-opening. The response to the request above revealed three cultural models of young people’s understanding of the connection between science and the real world:

1. Science is connected to the real world by the amount of inventions made by science, which we use on a daily basis. Science is a helper; it helps us every day.
2. Science is connected to the real world because science lies behind many important processes like the growth of trees and plans – science is an enabler.
3. Science is connected to the real world because science is a way to discover the answers to any questions.
I will discuss each of these statements further shortly, after noting some overall points. All three points are about the importance of science in everyday life. These points show that, according to the students, there is something before science and without science, and also something else when science comes along. The cultural models and the shared idea show that young people notice the difference between our daily lives with or without science. The cultural models of science provides answers and suggests that science can explain almost everything and is a powerful tool to use. Young people show awareness in their responses of the importance of science. The results show how young people see science as something which makes life easier and how they firmly believe that science (they hardly mentioned scientists) have the answers and that science is the backbone of any query. It would be interesting to know whether young people believe that they personally can do science – for example, whether they can invent anything – or whether they believe that science is just for a specific group of people. The cultural model and the shared idea that scientists have the answers is also a commonly-shared idea. The way that participants answered this statement shows how strongly they believed that science has the answers and how it can help with anything and make our lives easier.

According to the young people’s answers about the connection between science and the real world, all of them see science positively, which raises the question, again, of why, if young people have these positive views towards science, the number of young people who are interested in pursuing science in the future keeps decreasing (Sadler et al., 2014, Cooper and Heaverlo, 2013, Shahali et al., 2016, Warne et al., 2019). Given all the positive views about the importance of science in our lives, why are young people not interested in doing science, and why do some of them say science is boring (Prokop et al., 2007, Lyons, 2006b, Jenkins and Nelson, 2005, Shirazi, 2017). This positive view towards science has led to us speculate whether young people might be not interested in science and view it as boring because they see the connection between themselves and science as vague. Next, we are going to discuss each cultural model that emerged from the second statement.

The first cultural model or shared idea about how young people see the connection between science and the real world was:

1. **Science is connected to the real world by the inventions made through science, which we use on a daily basis.**
From young people’s perspectives, science is seen as a helper in the real world. The photos for this request showed cars, lights and electrical wires to represent how science helps us on a daily basis. Using pictures provides distinct views that are not found with text or text-based language. Pictures allow people to talk about different kinds of things in different ways (Carlsson, 2001). The participants supported their views about the connection between science and the real world by taking pictures of cars, buses, electrical wires, bulbs, mobile phones and nature. The young people’s responses showed that they understand that science facilitates our lives and that it has become impossible to live without the inventions scientists have created. Society values science because of the contributions of scientific knowledge that assist in satisfying many fundamental human needs and advancing living standards (Funes et al., 2014). The cultural model here demonstrates that the role of science is significant in everyday life. Young people clearly recognise the importance of science on a daily basis. However, this belief about the importance of science has little influence on young people’s relationship with science in science lessons and performance in the science classroom.

2. Science is connected to the real world because it lies behind many important processes like the growth of trees and plans – science is an enabler

Young people view science also as an explainer of anything we might wonder about. The participants gave the example of science being an explainer of things like how trees are grown. Also, because science helps the trees to grow, we can grow our food on the trees, so the benefits come back to us and meet human needs as well. Moreover, trees produce oxygen, which is an essential element of life for many living creatures. These views show that young people value science and have very positive perspectives towards it, and it also shows that young people appreciate the importance of studying science.

The shared idea here, therefore, is that, because of science, we can explain how trees grow. In other words, and based on the participants' views, science is connected to the real world because science helps the trees to grow. Science makes our lives easier, and also helps the trees as well. The participants know that science is involved in the trees growing, but the information they have is incomplete, and they struggled to explain further. I am not sure if they still remember how to interpret the photosynthesis process or not; however, that is not the focus of the research. I assumed that the students remembered the photosynthesis process because they can see and
notice changes in nature. The results showed that one of the obstacles that students are facing is that they cannot see the connection between science and the real world with their own eyes, and not only as its written in textbooks. The PEI results show that some students want to know more about science. For example, some students want to know the science behind metals and minerals, topics they were covering in their science lessons. They were very interested to know how, where and when the elements were discovered. They seem not to accept it as a topic in their science lessons without this extra information and feel that something is missing. They want to know its history and origins; this may show their curiosity and interest in science.

It is beneficial to keep young people asking about science. It is essential to find ways to navigate these questions and encourage them to ask more. We assume that by eliciting young people’s questions and doubts about science, we will strengthen and support the relationship between young people and science. The issue is currently no one knows about young people’s hidden concerns and unspoken opinions about science. We, as science educators, may never ask, and the students may never come to us and ask themselves. I think we do not have this kind of relationship yet because teachers are too busy with large class sizes and loaded schedules, and focus too much on exam results. Nevertheless, the main focus and the ultimate goal for everyone in the education sector is for students to get better results. Exam results are the primary measurement for success in the teaching process.

3. **Science is connected to the real world because science may have the answers.**

Attempting to spark young people’s curiosity and interest is not a new topic. Understanding the concerns of young people can be a door that leads us to better outcomes. The desire to explore the world is one of the ways that participants see the connection between science and the real world. Layla pictured the moon and talked about space; she claimed that by studying science, we will know more about space. The shared idea that science can help us to find the answers and explain the world is vital. It is worth noting that the Department of Education in the UK has Some exam bodies have removed ‘Space’ from their KS4 GCSE curriculum However, the participants mentioned ‘space’ many times during the photo-elicitation interviews, so studying space is clearly interesting for young people. The participants mentioned that ‘we do not know why they decided to remove the space [chapter]; it was fun’ – this shows how young people feel voiceless in their own education experiences.
6.3. Disconnections between science and the real world

<table>
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<th>The third research question is:</th>
<th>How do students make meaning to describe the disconnection between science and the real world?</th>
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<tbody>
<tr>
<td>The photo relating to the ‘disconnection’ side of this question was:</td>
<td>Take a photo from anywhere showing how science is disconnected from the real world.</td>
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This request was a challenge for me as a science educator and science education researcher. The way that young people view and interpret the disconnection between science and the real world was fascinating. The outcomes of this research can be used to shift our way of teaching science. Besides assuming we know our students very well, we also take their understanding of and relationship with science for granted. Basically, we assume that, because we were kids who studied science once and now hold degrees and careers in science, we have been there and we know better. The literature is full of research and activities that have been done to engage students in science inside and outside of school. Nevertheless, we rarely listen to students’ perspectives on how they see science verbally.

The difference between this research and other available research that, in the other research, there is little attention to listening to the way young people make sense of science. This specific request to show how the real world is disconnected from science was challenging for my participants as well. When I received the photos before the interviews, I looked at each photo to try to match the photos with their corresponding statements. My guesses about the previous statements were sometimes correct, however, in the photos for this statement of disconnection, all of my guesses were wrong.

At the beginning of the research, before any data was generated, I was more interested in understanding how young people saw the connection between science and the real world than the disconnection. However, the responses to this statement blew my mind. The responses to this request show various cultural models. Moreover, they show that young people have the capacity to visualise science in the real world. However, the existing cultural models which focus on exam results, and which position science students as having nothing worth saying, and the voicelessness of students may have reduced the chance of visualising the relationship between science and the real world. For example, the group wanted to know more details and...
were interested in the history of scientific properties. It was apparently essential for them to know the history behind the experiments and the things they studied in science classes.

They perceived a disconnection because they were not sure how everything begins. This group claimed that the lack of lab experiments reduces ability to recognise the connection between science and the real world. The data show that there is a misunderstanding between young people’s opinions about the importance of doing a lab experiment and the science teachers’ opinions. In this study, the science teachers appear not to prioritise experiments because they are unconvinced of their value. The results, as discussed in the previous chapter, show a mix of curiosity, unshared ideas and a kind of real, unspoken interest in science. Five cultural models emerged from this research question:

1. **Science is disconnected from the real world because science is a statement of information.**

The first cultural model presents the disconnection between science and the real world as resulting from students only seeing science as the scientific information we learn and read about in school. Science means facts and information. I am going to discuss one example of this in detail in this section. One participant who held this idea offered food labels as an example. She took a photo of a food label that presented the nutritional information. The participant knew that nutrition labels exist to help people choose between products and to keep track of the amount of fat, salt and added sugars they consume, for example. Despite this information being useful, and despite the fact that the students learn how to read nutrition labels in their science lessons, the participant expressed that she thinks this shows the disconnection between science and the real world. The participant disconnected this valuable knowledge and the essential role of science in the example from the real world. The participant knew that science provided us with such information, however she still believes that it is disconnected to the real world. Again, maybe that is because the participant studied the food label in science class. Alternatively, this could be because such nutritional information is not visual.

I suspect that when we as science educators teach students how to read food labels, we hypothetically assume that the students already know such information is going to help them in real life. Moreover, as a result, we tend to assume that students see how science is connected to the real world, and not the opposite. I suggest that our tacit goal as science educators is that, when students go food shopping, they can make smart, healthy choices. Furthermore, we, as
science educators, believe and take for granted that students will somehow see how science is connected to their everyday life and that it will serve them daily. However, the data shows that, while they can relate things like cars and electrical wires to science, that may be because they are visual, and it is not the same with scientific information. This study shows that young people separate science from the real world, even though they can practice what they studied in their science classes outside of school.

As science educators, we are aware that relatively few people care about reading the labels before buying food, unless they are especially interested or their doctor suggested that they should, for health reasons. The participant who took a photo of a food label justified her view by saying that ‘the food label because food label [is] not really related to the earth. The food label is like... food has a label, talking about fat and weight and information’. When she was explaining, I got the feeling that she thinks the food label is not real. From the participant’s perspective, the real world is the earth, so to be connected to the real world, something must be related to the earth. This participant’s view made me wonder if this means that scientific information and facts are not real to her as well. Maybe the problem was that reading a food label is not easy or understandable for everyone. There may be a job to do in helping students to see how information and data can influence how they live in their real worlds.

As educators, our understanding is that we are teaching young people about food labels to improve their lives and raise their awareness, however it was not apparent before this study just how young people deal with this scientific information, or how their way of thinking is separated from the real world. I believe that it is important for science teachers to show that science is connected to our lives and not only a subject at school, and that science is not boring, hard and only for specific people. I would be very surprised if the participant’s science teacher had not talked about the importance of understanding or reading the food label; however the way that young people perceive this scientific information and view it as separate from the real world was not expected.

Food labels and ingredients, in term of vitamins and minerals, kept showing as an example of the disconnect between science and the real world. One of the participants justifies why she thinks the vitamins and minerals in food are an example of the disconnect between science and the real world; she said ‘if I ate food, I do not know if it has iron [in] it. I could not say “oh, I ate iron”, so this [is] only science’. Her perspective shows two cultural models: the first is that

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2 In Arabic, ‘we’ is used frequently in arguments and discussions; it is widely recognised that this is the speaker’s view and does not imply that they are making assumptions on behalf of others. Here, I have been additionally careful to emphasise that I am not myself making any such assumptions.
scientific information is only science; the second is that if something is not visible, this means it does not exist. Science for some young people, therefore, is a set of information and facts and could not be connected to the real world. This view might have resulted from the participants studying this fact in science classes or because it is not visible, so if they cannot see it in the real world, it does not exist. The visibility issue will be discussed in the following paragraph.

2. **Science is disconnected from the real world because science is not visible.**

The second cultural model that emerges from the statement of disconnection is the fact that connections between science and the real world are always clearly visible. In other words, the connection can be seen by the human eye. The example given was of things that are not visible, but which represent science, like the air, where iron comes from and the origin of scientific discoveries. Each example is explained in detail in the results chapter. It was surprising that young people wanted to know more in-depth information about the school science topics. From the tone of voice and body language of the participants, you could tell that they were really interested and wanted to know more. They struggled to believe in the existence of iron in their food. As well, the air we breathe in, oxygen itself and the whole respiration process are reduced to sets of facts and information from science.

My claim is that these perspectives have never before been in such a systematic way. The use of photos to explain young people’s understanding shows the power of this method. The responses to this simple photo request show the desire of young people to know more and it shows that they have a lot of questions and are interested in connecting the dots. It also shows that young people want to be introduced to each topic from the beginning. We know that our topics and lessons are connected to each other. In other words, all curriculum content is linked to the following academic year, and we introduce every topic to the students gradually. However, it seems that this is not enough and that students tend to forget what they had learned the previous year. In addition, we have to consider new students who come from the different education system and are used to different ways of teaching science. Most of the participants are immigrants; some of them just recently moved to the UK. The result of this study shows that young people have quite different views from those of the curriculum developers and science teachers. Again, this is because either the curriculum developer or the science teacher or both are following the cultural model that takes young people’s perspectives on science for granted. I do not know if science curriculum developers ever consider the fact that young
people may want to know more in-depth information or may want to know the story from the beginning. I did not find any research about student voices or views and how they are used to form science curriculum content.

We may think that introducing any topic from the beginning is just an extra detail and that it would be hard for young people to understand because of their age. Also, we may think that they already know such information, and that there is a high chance that they would remember it from the previous year, or we think the examples given in the introduction of each unit is enough to refresh young people’s memories. The participants complained about not doing many lab experiments, which they believed would help their understanding. I assume that they are interested in experimenting, as it would let them see what happens from the beginning of a process. The importance of a lab experiment is still often not considered, especially for science teachers. I talked with a science teacher about why classes do not do many experiments. The science teacher started complaining about how experiments are time-consuming, how it’s hard to deal with lab technicians and said that ’the students will forget the experiment immediately; it is not going to help them to memorise the lesson’. What the students perceive as necessary to learn from a regular laboratory exercise is probably affected by their teachers’ objectives (Högström et al., 2010). The young people interviewed believed that lab experiments would help them study science and achieve better results, whereas the science teachers had another opinion. However, the students may never have shared this desire with their science teachers. Also, the science teachers’ opinions about lab experiments should be considered. We need to do more research to find out if it is true that young people quickly forget the lessons learned from experiments, and to what extent lab experiments can support and improve young people’s attainment levels in science, specifically for high school students. In setting up such research, we should consider not just the direct effect of one experiment on recall of a reaction or principle, but also the indirect influence on the way that young people understand what science is.

3. Science is not connected to the real world because science is man-made.

The cultural model here is that young people believe that science is a process of human intervention and human creation which takes place in the real world. Young people view science as a power or force used by human beings. An example of something not man-made is the sky. The blue sky was an example given by participants of the disconnection between science and the real world. For example, participants said ’because the sky has nothing, [it is
not] man-made’ and ‘the sky, because people cannot make the sky’. It is hard to distinguish these participants’ responses and determine if they believe in the power of science or the limited power of science. One of the participants used the word ‘cannot’, by which she meant the deficiency or limitation of science. I cannot assume whether she views science as either a powerful tool or limited ability. It may be worth investigating young people’s perspectives on what science can and cannot do.

The sky was an example given by participants of the disconnection between science and the real world. The reason they used the sky as an example is because it is not man-made. This response shows that some young people have a shared idea of what is science looks like or what science does. From my perspective, science seems to be about changing and making. The word ‘man-made’ refers to science as something made and discovered by humans and developed by humans as well. Anything man-made, therefore, is only science, and is disconnected from the real world. The real world, for most of this same group, is nature and natural resources.

This view shows how science is separated from the real world for these participants. In the previous cultural model, young people saw science as separate from the real world when they could not see the actual science with their eyes. Here, young people see the sky and claim it is disconnected because people cannot touch the sky or change it. Science seems to be a set of scientific facts and visible changes. This way of viewing science, as man-made and about making change, represents a positive view towards science. The cultural model here is ‘science as a powerful force’. This force can reach and change anything; this is the same view as the one Emma holds about science being everything and everywhere (we discussed Emma in chapter 5). There was a cultural model that regarded science as infinite and somehow connected to everything. On the other hands, if young people think that science cannot reach and make changes everywhere, there is an idea or cultural model that science is a limitless power.

Another cultural model about science is that it is man-made, and that the real world is not man-made. This cultural model is different from the previous paragraph. It shows the shared idea that only things that are created and constructed by humans are part of science. However, the data did not show, in contrast, that anything not made by nature is the real world. Some young people still think that science is what helps trees to grow, so, in this case, science is connected to the real world and science is not only man-made inventions.
The data show there is a confusing idea of what is science and what is not science. However the main goal was to highlight the connection between science and the real world, so that, maybe, when young people recognise the connection, it will improve their relationship with science. In some examples, the participants have an idea of what science is, like the example given by the participant who said she thinks that coal is not connected to science because it has no wires. She knew that we use the coal to generate energy and she studied the coal in her science lessons, however she thinks of the coal only as being part of nature, even though she studied this topic in science, because the coal has no wires. Wires, from this participant’s perspective, are what makes something ‘science’. She shared the same view as other participants when she articulated the disconnection between science (the lightbulb in the room) and the real world (the sunlight in the room). Because both lightbulbs and sunlight do the same job, they are not the same. Her comparison of lightbulbs and the sun outside is deep. She considers the sun to be the real world and the lightbulb to be representative of science. The participant was looking for an example of two things that provide the same service. The link between the lightbulb and the sun is interesting and shows a positive view of science and recognises the importance of science in our lives. But there is another consequence of the view that science is only about what is man-made, and that is that science has nothing to say about the real world that is not man-made. According to this view, biology, for example, is not science, unless it is biochemistry and involving synthesis of medicines, or the construction of artificial limbs. This then becomes a very limited view, which excludes much of science and scientific practice.

4. Science is a subject in school only.

The fourth cultural model simply views science as a subject at school. The outcomes of many studies have shown how some students completely disregard science in their lives outside of school. Jenkins and Nelson (2005) study shows that many young people simply say ‘science is not for me’. This cultural model shows how science is separated from the real world for some students, and we still do not know or have clear explanations for why this is. One participant who shared what I would call a ‘careless attitude’ towards science was in Year 9, and she had been placed in the high attainment group. The science teacher had nominated her because she was a student doing well in science and was very engaged during the lesson, and also because she was an immigrant. It was shocking to me that she was in Year 9 doing very well and still viewed science this way. Maybe this participant just viewed science as something she has to pass. She said that ‘if my science book is not with me, that means I am disconnected from
science, because I do not have my science book’. At the same time, this girl took a photo of laundry detergent as an example of science at home. She said this is a science because it contains chemicals. She did not bring the example that shows how science is helpful and connected and improving our lives. She gave the example of the laundry detergent, only because it contains chemicals, which is an abstract view. She did not talk, for example, about how the detergent helps us to clean our clothes. The detergent was her example of science from home.

We can see two patterns of how young people see science as disconnected from the real world. The first pattern is that some young people strongly believe that science is connected to everything and is everywhere, so they completely reject the idea of science being disconnected from anything. On the other hand, other young people consider science as a stand-alone thing, and believe that the real world is another thing, so they see a complete separation between science and the real world. Therein lies the art of applying cultural model theory to everyday practice. It clearly shows that there are significant differences between the way we as adults and science educators think, and the way other people (in this case, young people) think. There is a massive amount of information outside of school that young people receive every day from many different sources. The media these days keeps updating society with knowledge related to science, like information about the latest scientific inventions, global warming issues, or various economic or public health crises. We are aware that not every single student has access to smartphones and the Internet, but the majority do. These days, without even having access to the internet, young people can see advertisements everywhere. Most of the time, the advertising sings on the road or on transportation platforms inform people about the latest products and innovations, regardless of their availability to surf the internet. In the context of school, in one classroom, there are students from different backgrounds and ethnicities and with different perceptions of science; in some cases, the students come from a completely different schools or education systems. We have to find a way to explore their cultural models and consider and respect these cultural models. For example, in this study, the participants came to England from around the world and faced language barriers, a new education system and, sometimes, conflicting beliefs.

I would divide the participants’ perceptions on the disconnection between science and the real world into four parts. First of all, young people think science is disconnected from the real world when they cannot see the connection. For these students, the connection apparently needs
to be visible. For their examples, these participants identified the air, metals and vitamins in food as science and said they not connected to the real world because they are not visible.

In the second model, science is about changing and making. As a result of this cultural model, anything that cannot be changed belongs to the real world; for example, the sky, because no human can touch or change the sky, and therefore it is not related to science. This point of view represents two cultural models or shared ideas. The first one is how science is about changing and making, and this is how we are able to identify science in everyday life. The second point view is that science is man-made, which means everything that is made by human beings is science.

The third model, for some young people, is that science is still just a subject at school only. This belief has nothing to do with their achievement level; many participants who ascribe to this view are doing very well on their exams and still see science only as a subject in school. This study shows that this group can have an incredibly positive attitude towards science, however it was hard for them to formulate a relationship between their own lives and science, so they claim that the moment they are not in the science class or carrying a science book they are therefore disconnected from science.

In the fourth model, young people are interested in understanding the origins of significant scientific discoveries, like how experts came to recognise the vitamins in food and how they discovered metals. Also, young people are interested in doing lab experiments, no matter what other sources are provided, like videos or pictures. Young people want to do more experiments, as they believe that would help them to improve their relationship with science.

**Border crossing and cultural models**

Recognising the cultural models and the shared ideas between young people directs us to explore the research data in relation to the border crossing theory. The theory presents five types of borders that young people are faced with in science. The idea behind this theory is about the movement or the crossing from one subculture to another. Sometimes, defining the subcultures in certain groups is easy and possible; for other groups, it may be hard. By identifying personal background, family, friends, peers and life outside of school, we suggest that it can be possible to recognise the cultural models that young people hold. The ability to recognise the cultural models will help to identify those borders and maybe find a way to help
young people overcome them easily. Knowing which subcultures an individual is part of is not possible in many groups and situations. Cultural models offer a more direct approach to describing the shared and different ideas that are held within a classroom or community. However, identifying those cultural models as I agree, cannot be done by traditional surveys or interviews. It should be done by exploring young people’s beliefs in relation to science by using methods that elicit students’ voices. We have to offer young people the chance to express and share their challenges, fears and barriers in studying and processing science.

The theory of border crossing clarifies that students have to cross, however it does not suggest any key to overcoming these borders other than studying the subculture of science classes and the subculture of the school (Aikenhead, 1998). Nevertheless, there is some value in updating the groups posited by Aikenhead (1996) in terms of the data from this study. In light of the new data, the first type of student can be called ‘the potential scientist’. The potential scientist where the family and friend are corresponding with the world both in science and school. Sometimes it is easy to recognise this group of students; the theory of science capital plays role in this group as well. In the current research, a number of participants showed real enthusiasm towards science, which places them in this first group. However, one such participant didn’t seem to have issues with family support or science lessons, but rather getting high marks on science exams. Ameerah talked about how her family and friends support her dream of becoming a dentist, while her exam results tell a different story. Moreover, her science teacher said that ‘when talking with Ameerah, you can see and feel how interested she is in science; she tried to put effort [into] getting better exam results but without any improvement’. This student, in my opinion, already passed many borders: she came to England as a refugee and neither one of her parents was working at the time of the interview, so she does not have any science capital. However, she said that she believes she is going to be a scientist. She seems to have crossed the borders of a new school, a new language and a new life, but she is still stuck on the border of the cultural model of education decision-makers, which is that ‘the exam result makes the final decision’. I remember the head of science department saying that ‘all of them want to become a doctor or a lawyer’. This sentence shows that young people may have support from family and community outside the school, however, in this case, the border is inside the school or education system.

Aikenhead’s second type of student is ‘other smart kids’, whose family and friends are compatible with school but not with science. This group does well in science classes, however, they are not interested in pursuing science in the future. Faiza is a prime example of this group;
she views science only as a subject in school. She summed up her connection with science as dependent on the presence of her science book in her school bag. Faiza already ascribes to the cultural model of science as merely a subject at school. Faiza’s cultural model of science tells us even without applying the border crossing theory that she is doing well in science; however, she is not interested in pursuing science in the future. Faiza has managed to cross the border between the subcultures of family, friends and school and get high grades in science without having any interest in doing science in the future. This group manages to cross the border but does not see science as connected to their lives. The lack of connection between science and the real world creates this obstacle. However, because such kids are smart, they can manage to pass these obstacles. We do not know how we could make science more related to their personal lives and whether that would change their perspective on the connection between science and the real world.

The third type of student is those who present a mystery: ‘I do not know’ whether their families and friends are inconsistent with the world of science and school. This group can be recognised from a few characteristics, as the researcher suggested in (Aikenhead, 2001). They are enrolled in the minimum number of science courses and are also only interested in passing tests. The researcher claimed that they are utterly different from the two previous categories; however, I think they ultimately share the same views and cultural models about science (Aikenhead, 2001). This group sees no connection between science and their personal lives, and it is possible that more perceptive and timely engagement, perhaps involving parents as well as young people, from science teachers and the school could play a role in this. from the world of science and their school plays a significant role in this.

Moreover, the inability to see a connection between science and the real world is also significant for this group; if they can pass tests, why do they not push harder to get better results? As well, the cultural models of this group have been taken from family, friends and society, who all subconsciously influence this relationship. The researcher classifies this border crossing as a hazard because it is a vague relationship in all directions.

The fourth type of student is the ‘outsider’, whose family and friends conflict with the world of science and school. The researcher views the border crossing for this group as impossible because of the conflict between all of the subcultures the person is surrounded by. The members of this group tend to be from disadvantaged groups. The researcher has also noted a few specific characteristics of this group, like academic failure and causing problems for teachers, such that
it becomes impossible for them to achieve any good results. Sometimes members of this group end up leaving school. I assume that knowing the cultural models of this group and understanding how they see the connection between science and their lives would help to facilitate their movement across borders. Knowing the cultural models of the family, friends and society the students live amongst and in would also help to identify how to improve the students’ achievement in school.

The key additional element arising from this study is that exploring young people’s cultural models can be accomplished by listening to the students’ voices. Stephens et al. (2012) study shows that student feels disconnected from their teachers; they feel ignored and left behind, and that feeling has been shared with in this study too. It would help if there was a space for talking and listening to students’ perspectives about the curriculum, about school and their teachers. There is currently no safe space for young people to express themselves. The education system is going in one direction and the only student voices we can hear in the form of exam results.

The fifth type of student is the ‘inside-outsider’, whose family and friends are incompatible with the world of school but are possibly compatible with the world of science. This group is similar to the previous type, and they face the same struggle, however, the worlds of family and friends do not support the students’ interest in science. The same solution is suggested for this group: it would help if we recognised the conflicts they face and the reasons behind their problems. Again, the cultural model may help because it is about sharing ideas with the group. In this case, when we recognise or explore the cultural models of this group, we will be able to find ways to help. Another side of this, beyond the scope of this study, would be to deliberately explore the cultural models of the school, and the teachers specifically, regarding science and students, so that, they will be able to facilitate the crossing of borders for whoever is struggling.

When the head of the science department and the science teacher said ‘they all want to be a doctor or lawyer’. They were smiling and taking for granted that young people only say this for the sake of showing off in front of each other and that it is not real; the head of the science department suggested that young people were just showing off. What if young people do want to be doctors or dentists but are having trouble crossing the borders and are facing conflicts in the clash between their real worlds and their school’s science culture models?

We suggest that exploring the cultural model could nourish the educational experience for everyone. The border between one culture and another can be a real problem. Moreover, even
when young people make the crossing, all ages do not share their misunderstanding and struggle they are facing while crossing, the problem will remain, and no improvements will occur. I assume there are more borders that young people have to cross in term of connecting science to their everyday lives. The shared understanding of how science is related to everyday life is significant.

I would like to make a final reference back to the literature at the end of this discussion about Science capital. How much science capital a young person has will indicate his/her relationship with science. As Archer et al. (2015) suggested eight areas that influence young people to pursue science. They are science literacy, science-related attitudes, values and dispositions, knowledge about the transferability of science (skills, knowledge), the consumption of science-related media, participation in out-of-school learning activities, family science skills, knowledge and qualifications, knowing people in science-related roles and jobs and talking to others about science in everyday life. We discussed and explained each dimension in detail in the literature review chapter.

Science capital has influence, but it is limited. The science capital theory is applicable within a specific group, like a high- or middle-class group. However, it is hard to apply it to a disadvantaged group. Science capital speaks to the significance of already being well-educated and understanding the importance of science in one’s life. My argument relates to how we can create or find science capital for disadvantaged students. As well, as all science capital dimensions exist outside of school, we cannot ignore the power of the cultural models of the family, friends and society. Knowing the shared ideas about science outside of school is useful. During the observation phase, one of the students said she was very interested in doing science in the future, however she was worried about the tuition fees at university. This student, no matter how interested she was in science, had already learned from her family that university is expensive and that there would be no way for her to afford it. We cannot blame the family, because they may have just moved to the country, or they may have received this information from a relative or neighbour. Money is an issue for this group and can be an obstacle that young people face all the time; they might be ashamed to share their fear. Having a space where young people can share their misunderstandings in relation to pursuing science and their cultural models about how science is connected and disconnected might be a way in which the connections that build science capital can be formed. In my view, this could happen most systematically and affordably if it was built into the teacher’s role. In the final chapter, the
significance of the key findings will be explored further, in relation to research, policy and practice.
CHAPTER 7

Implications of the Findings

The goal of this study was to explore young students’ perspectives on the relationship between science and the real world. The outcomes of this study provide powerful implications for reframing the science education field at the most basic level. Moreover, the results of the study have contributed to new knowledge in this area and have provided valuable insight into an area that has previously received minimal consideration from a science education research perspective. Applying a PEI method exposes a vital aspect of science education from the perspective of young people. There is a clear message to science teachers, curriculum designers and policymakers in this regard, about listening to and exploring the voices of pupils in order to improve and support the quality of science education.

In general, young people’s perspectives are clearly missing from the constitutive voice that determines the science curriculum and science teaching. I placed young people at the centre of the model that I developed at the end of Chapter 3 pg. 48 called “Caricatures of influence: Identifying the key institutions and influences of young people and the cultural models of science and the real world (and the relationship between them) that are held by those institutions and influences”, and which highlighted the absence of their perspectives in policy formulation or enactment. This indicates that only the views of scientists, science educators and curriculum policymakers are accepted and perceived to be vital in terms of shaping those aspects of science that pupils are required to study. There are some aspects of science that young people do perceive to be relevant to their everyday lives, such as health, career choice, the environment and technology. The result from this study shows what learners consider to be relevant and how this information can be used to reform the current science curriculum in a way that could simplify the delivery of relevant science, including the relevance of context, purpose and method.

To find out the relevance of science in young people’s lives, we decided to use the term the ‘real world’. Using the term ‘the real world’ revealed a lot about students’ views and perspectives on their relationship with science. Some students think science is what they do in science lessons, like the topics they cover, while others see science as connected to the real world by the inventions we use in everyday life, like the cars we drive and the lights we turn
on inside our houses. On other hand, the results show that science is seen as disconnected from
the real world for some students, and is seen only as a subject in school. Moreover, the study
also shows how students can engage very well during class and do well on exams but still
believe that science is separate from things in their everyday lives. More than this, young
people have many unspoken ideas and opinions about how they perceive science that we do
not know about. They actively and independently make sense of science in relation to other
significant elements of their lives, such as family, religion, and money.

It has been claimed that if young people are not comfortable or happy, they will not learn,
regardless of how well the teaching practices are designed (Si’ayah et al., 2019). Despite the
claim that young people feel good about becoming educated, the choice by students to study
science may arise for several reasons, such as science being both interesting and beneficial for
future work. Consequently, if science classes contain no perceived relevance to young people’s
lives, maintaining and nourishing their interest will be challenging, if not impossible.
Therefore, creating science curriculum, or a science classroom that is influenced by the spoken
needs and interests of young people may generate a curriculum that is more relevant to them.

The first photo statement was based on a question about how young people view the real world
only. The responses were significant. The real world as nature was the most repeated theme.
Nature seems to be a cultural model that is commonly shared by students. Many participants
delivered the same idea that nature is the real world, even though they took different photos.
We did not face any problems in having to explain the meaning of the ‘real world’ to young
people. As I mentioned before, for half of the participants, this question about the real world
was apparently a familiar one. Some participants, however, were both surprised and angry
when I asked for further explanation about their views.

The next photo statement was about the relationship between science and the real world. Many
participants stated a belief that science is about meeting human needs. The PEI was a suitable
method for opening young people’s eyes to what science is and how it serves us in everyday
life. The perspectives and answers elicited show how crucial it is to ask questions that will
inspire students to pay more attention to the importance of science and understand how science
serves and helps us on a daily basis.

The third statement was about the disconnection between science and the real world. The word
‘disconnection’ had a considerable impact on the participants. It shows that young people
sometimes think science is a set of information and facts only. It turns out that young people
are also interested in seeing examples of what they learn about their science lessons, like metals, in real life, in order to connect science to the real world; otherwise, it is only scientific information that belongs to science classes and science books.

The results from this study taught us that young people have an issue with visibility. The data shows how visibility is essential for young people to understand science. I think we believe in young people’s imagination, but this study shows that students’ imaginations and the previous year’s science curriculum are not enough. For young people, it seems as if it is not enough to see the final products; they want to see the details. The link that participants made between the sky and the real world being disconnected from science because the sky is not manmade was amazing. This means that young people see or understand science as human artifice. From my perspective, it is a good sign that young people view science as being about change and discovery. What I do not understand is why some young people seem think science is a separate entity from the real world, and that they are not connected.

From my experience, both as a science teacher and during the observation period of this study, classrooms operate like marathons; the teacher is worried about finishing on time, student engagement and behaviour and moving forward with the curriculum. On the other hand, the students are worried about the exams and results. The classroom seems like a hamster wheel; no one has the time to think outside the box and everyone is busy and concerned about the next steps; all they want is to ‘survive’. Experts and scholars spent a massive amount of time trying to develop their teaching technique and curriculum and on improving the entire studying experience, but the results show that the number of young people not interested in science keeps increasing. The result of this study shows that young people’s interpretations of science are quite significantly different from the science education community’s. Some young people’s ideas were large, some were deep, and some were large and deep at the same time. Other interpretations were simple and superficial, while some showed an investigative approach and seriousness about science. By ‘superficial’, we do not mean ‘nonsense’, but rather that young people are talking about the basics without genuinely exploring those ideas. It seemed as if some of the participants simply repeated what they were able to recall from science lessons.

7.1. For students
The study shows that young people have variety of abstract ideas about their understanding of science. These ideas come from many sources; one that we have discussed in this thesis is
culture. Young people do not mind sharing their understandings, thoughts and concerns. However, exploring young people’s perspectives is dependent on how and when and with whom they can share it. The study suggests that considering young people’s cultural models of science education potentially alleviates the achievement gap and the students’ sense of belonging. According to (Fryberg et al., 2013), students may feel a better sense of belonging and inspiration when the educational perspective matches up with their own cultural perceptions of self. In light of this, we think if young people’s perspectives match up with their own cultural models of connecting and disconnecting science to their lives, it would help them to perceive science in a different light.

The use of the photo elicitation method encouraged the students to think deeper and looking for explanations and solutions in some cases. The photo elicitation method freed students to share their personal understandings of science. I think we, as a science education community, take young people’s understanding of science for granted. In reality, the science curriculum is not the only source that nourishes students’ relationship with science. These days, young people have access to a vast amount of knowledge outside of school, books and TV. They can type any question into a search engine and open doors for new knowledge and new ways of understanding. School science and science teaching should be able to cope with this change in order to continue to be the main reference and guidance for young people.

7.2. For teachers
The model in Chapter 3 describes the influence that teachers’ cultural models have on young people’s experience of science in school. This study provides a perspective which can help teachers to challenge and develop their cultural models. It shows all teachers (not only science teachers) that young people have unspoken opinions and unshared perspectives about what they are studying. Because of the pressure of exam results, some students use the Fatima’s rules to pass exams (the Fatima’s rules were explained on chapter 3). Education today focuses on exam results in terms of grades rather than in terms of creativity. Creating a safe place for young people to discuss their ideas will reveal a lot of hidden problems, struggles and suggestions, and to young people, it will mean that they are recognised as active agents worth listening to. The generations are changing, and their ways of understanding and developing knowledge are changing, too. Understanding the background of students is essential; this can help to explain why one student appreciates and enjoys science while others just see it as a
subject in school. Some students really valued science, while others simply repeated as much information as they could remember from their science lessons. The PEI method shows that students are willing to express themselves and criticise the curriculum and teaching methods. The results also show that students were willing to be critical of about the way they are taught, including the lack of experiments, since they viewed lab work as very important.

The PEI not only helps science teachers to understand their students, but also helps teachers to understand themselves and explore their beliefs about how young people perceive science (Reference model in Chapter 3). For example, a science teacher does not believe in the power of lab work and the benefit of doing experiments; she believes that young people will forget the experiments as soon as they leave the lab. The science teacher feels that doing experiments is time consuming because of the process of having to sign in and out lab materials and, additionally, due to having to deal with the lab techniques, from booking the equipment to preparing the lab and returning everything after the class end without any damage or losses. The science teacher, therefore, claims that she does not have enough time for all this extra work. Another belief held by the science teacher is that all the students want to be doctors or lawyers, but they are not going to achieve that, an assumption that is based on the exam results only. I felt sad about those young people who want to do something related to science and for whom science is apparently interesting and might be an option for their futures. Nevertheless, despite giving up on science so quickly, I do not think young people are lazy as much as that they do not see how science is connected to their lives outside of the cultural models they have.

The science teacher’s comments inspired me to talk with a lot of the students about what they want to do in the future. I found out that not all of them want to be doctors. In fact, only very few students want to attend medical school; the rest want to do a lot of different things, like open a bakery or become a hairdresser or housewife. The science teacher may hold a cultural model that everyone wants to be a doctor or a lawyer, but in reality, this is not true. The study shows that for example, every student has a cultural model and their own way of interpreting the world and the people act without exploring the validity of these models. My claim here is that we do not really know what young people think about science or how they perceive science. The problem is that we do not even ask, and how should we be asking to get the truth, and not just what makes us relieved and happy and confirms that we did a good job? People’s culture and background are important; we have to know more about them; this is especially important in education. Exploring young people’s backgrounds and cultures should be done within a space of trust and safety. Allowing young people to discuss their ideas and misunderstandings
with the teacher will make a difference. Most students are mainly worried about their exam results. During the period of observation, very few of the students who participated appeared to enjoy their science lessons or ask challenging questions. The rest were quiet and busy with something else. The PEI method could create a space of trust between teachers and students. The photos themselves, even without the interviews, could teach us a lot. To help teachers understand the role of cultural models, they might have to explore their own cultural models, which could happen during the preparation program and training courses.

The study also suggests the necessity of rethinking the relationship between students and teachers. We need to find a way to avoid defining and classifying our students based on exam results. I think that we classify students according to two groups: those who could be scientists and those who are not smart or qualified enough to do science in the future. We forget that a career in science does not only mean joining medical school and studying physics. Science education includes dealing with a range of everyday activities, from fixing sinks and gardening to moving your body. This study makes me feel that we, as science educators and developers, are limiting our students and preventing them from having a healthy relationship with science. I believe the classification in the classroom, which is based on exam results, weakens young people’s confidence towards science. The participants in this study who were from the low ability group claimed a few times that they are not good enough and not smart enough, and that they feel ashamed because they want to pursue science in future, but they felt discouraged by being already placed with the low ability group. Additionally, teaching should build upon the interests and skills of young people (Leblebicioglu et al., 2011), and should explore young people’s perspectives and cultural models in relation to science. As a result of this, learning content should be expected to match the personal or societal backgrounds of young people. In the light of such considerations, education grows to become more significant and relevant to an individual. We have to be aware that young people’s perspectives and voices are powerful tools which are still, however, ignored in much science education research.

7.3. To policymakers

The study shows that there are collections of cultural models that are shared by all participants. Recognising and pointing out these models will improve the science curriculum, teaching methods and outcomes. We will know more about how to introduce science to young people and how to make science make sense in relation to their lives. The study shows that young people have questions regarding their lessons and exercises and opinions about how the lessons should be in order to improve their understating and level of engagement. But I believe that
these conclusions are not represented, or part of the cultural models held by many people with influence on the curriculum and practice in science classrooms in the UK (see model in Chapter 3 p39). Therefore, curriculum developers too should pay more attention to young people’s backgrounds and beliefs and to the influence of the highly significant cultural models which they hold. Considering young people’s perspectives and cultural models will help during the period of monitoring and training the teachers for changes to the curriculum. Curriculum developers in the UK should pay more attention to young people’s backgrounds and beliefs and to the influence of highly significant cultural models.

Considering young people’s perspectives and cultural models will help during the period of monitoring and training the teachers for changes to curriculum. Curriculum developers spend time exploring new fields of study and conduct interviews with different types of people to find out what is best for students to learn. However, I could find no single study about students’ opinions or perspectives on implementing the revisions to the science curriculum. I would argue that we focus too much on test results rather than students’ perspectives and voices. The curriculum is not exclusive to the curriculum developer; it also involves the teachers and the students. Each one plays a significant role and has different responsibilities. Everyone who is involved in the education process has unspoken opinions, cultural models and beliefs. Almost everyone has a potential voice in the education hierarchy except of the young people, not because we do not listen but because we rarely ask the right questions. It is as if we are walking in a circle around the problem when all we need to do to break the circle is ask different questions and consider different groups.

Listening to young people will make the process of change and improvement more accessible and faster. Exploring young people’s cultural models will help to choose the best teaching methods. Some pieces of the puzzle are still missing; in this study, we tried to look at the relationship between science and the real world. We also tried to understand how young people see the connection between science and the real world. Filling the gap by answering the questions young people have about science may increase their interest in science and strengthen their relationship with it. Considering young people’s perspective and cultural models will help during the period of creating and implementing the curriculum.

The results and findings of this study could challenge the cultural models held by many powerful stakeholders in education, when the contents and outlining of the science curriculum is opened for discussions and transformation. A vital matter to the revising of the science
curriculum is to re-establish the relevance, significance and impact of science learning, which is built on adjustments in science and technology and their position in society. Considering the multiple cultural models, principles, concerns, interests, priorities, expectations and desires of an individual are also important.

Although there might be some contextual factors that have an impact on effective learning, it is important and appropriate to consider young people’s perspectives on science content when designing the curriculum and teaching it. A sense of balance between young people’s views and the ideas of the experts would offer a great compromise. Teaching an interesting science topic certainly does not ensure that quality education will be delivered; nevertheless, it makes sense that young people will be significantly encouraged to learn about what interests them better than what they perceive to be boring and irrelevant.

7.4. Summary

In this time of growing diversity and living standards, I believe that the students we teach must continue to be at the forefront of planning, teaching, evaluation and responsibility. I suggest, to take account of this study, that modifying the science curriculum and teaching methods based on young people’s cultural models and considering the borders that young people have to cross may improve young people’s perspectives on their relationship with science. As per tradition, science has been taught with the view that all students could, and should, become practising scientists. Nevertheless, few students in science classes will, in reality, end up becoming scientists, but all students have the right to receive a high quality science education.

Science education remains an education for practicing science, not an education about scientific information. In school, the science curriculum is usually led by the resources required for post-compulsory, science-associated courses and scientific institutions. For a long time, the constitutive voices in the curriculum design process have been wide-ranging professional bodies, including scientists and science educators. The exceptions in this process are the voices of pupils who are the direct recipients of the curriculum (Osborne and Collins, 2001). There is a growing imbalance between science skills necessary for members of the public and the science that is taught at school, and there will surely be a continuing debate on the future of the science curriculum (Zohar and Barzilai, 2013). As science educators engage with pupils, the consideration of young people’s views about the role and content of science would be able to make a contribution to the science education community. Many academics (Driver et al., 1994, Anderson, 2006) have claimed that active learning experiences for students involve a
curriculum based on students’ thoughts and scientific interpretations, and that this will permit
the curriculum to be adapted in such a way that pushes students towards scientific knowledge
and understanding. The result of this study shows it is necessary to adjust young people’s views
on the construction of science education. The suggested way of accomplishing this is by
recognising how young people understand and value and seeing what is relevant to young
people’s everyday lives and their community. As well, it is essential to note that such views
cannot be the exclusive basis of the science curriculum. However, it is useful and makes sense
to realise and recognise that young people’s views can contribute to the ongoing debate.

In terms of the science curriculum, the focus is mainly placed on learners understanding
fundamental science facts, identifying science concepts, their knowledge about the nature of
science and their ability to analyse and write descriptions about what is observed and why what
is observed occurs. Nevertheless, less focus is paid to the science topics that inspire young
people to learn more. Walkington (2013) study shows that young people receive less instruction
on modern technology (a topic that interests them), like computers or experiments, in science
lessons.

Trying to modify the science curriculum according to young people’s cultural models, interests
and values is not, however, intended to devalue the currently accepted model of high-quality
science education. School science could be more relevant and meaningful to young people if
the science curriculum provides space for consideration of the cultural models that young
people hold of science and the real world. To some extent, that cultural models that young
people carry for school science. The study results have found out something of what science
is, to young people. It has demonstrated a great wealth of curiosity and wonder, even in students
who appear to have concluded from their experience in school that there is little for them in
science. Considering young people cultural models it will help science teacher to adjust the
science lessons in a way that strength young people relationship with science. When young
people able to ask questions and free to wander without judgment. The freedom of expressing
your struggle, doubt is healthy, and it will improve the quality of teaching. Considering the fact
that some student may come from very negative poor perspective toward science is very
important. This research shows that young people have questions and doubt; however, they do
not know how they would ask or to whom. This is the first study of its kind in science education,
aiming to understand the way that young people see science and their role and place in relation
to science. I believe that this can lead to further work which addresses these ontological
questions of what science is for young people. I hope to explore these questions in further work beyond this thesis.


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Appendices

Appendix 1: The University of Manchester Ethical approval

FW: ethical approval/fieldwork support

Andy Howes <andrew.j.howes@manchester.ac.uk>
Thu 09/03/2023 21:02
To: Samar Albalawi <samar.albalawi@postgrad.manchester.ac.uk>

1 attachment (240 KB)
FW: Samar Albalawi - amended ethical application

From: Deborah Kubiena <debbie.kubiena@manchester.ac.uk>
Date: Monday, 20 March 2017 at 09:48
To: Samar Albalawi <samar.albalawi@postgrad.manchester.ac.uk>
Cc: Monique Brown <Monique.Brown@manchester.ac.uk>, Elaine Jones <Elaine.Jones@manchester.ac.uk>, Andy Howes <andrew.j.howes@manchester.ac.uk>
Subject: RE: ethical approval/fieldwork support

Dear Samar,

I've just spoken to Georgia Irving who has confirmed that your original application submitted 17th May 2016 was approved, but hadn’t been confirmed in writing. The amendment submitted in November was approved by Lawes (see attached).

I am pleased to say that we can now proceed with your award for fieldwork support and a letter confirming this will be sent by Elaine Jones shortly.

With kind regards,
Debbie

Debbie Kubiena | Senior Doctoral Programmes Officer
Doctoral Programmes Senior Support: SEED
School of Environment, Education and Development | The University of Manchester | Arthur Lewis Building 2.025, Oxford Road, Manchester, M13 9PL, UK | Telephone: +44 (0)161 2753460 | Email: Debbie.Kubiena@manchester.ac.uk | Postgraduate Research Handbook

From: Deborah Kubiena
Sent: 30 March 2017 11:53
To: Samar Albalawi
Subject: RE: ethical approval/fieldwork support

Hi Samar,

https://seedweb.manchester.ac.uk/wikis/display/SEED/Appendix+1:+The+University+of+Manchester+Ethical+approval

2/2
Dear All,

My name is Samar Salem Albalawi; I am a registered Ph.D. student in the Institute of Education at the University of Manchester. My supervisor is Dr. Andy Howes. The topic of my research is **Photo elicitation interview (PEI): using photos to elicit secondary student perspective of connecting science with the real world.** The objectives of the study are:

(a) **To understand how the student makes sense of connecting science with the real world.**
(b) **To investigate how student fund of knowledge can help science teacher for creating a smooth transition of the scientific knowledge in the classroom.**

I am seeking your consent to conduct the data from your school. We are in the process of gaining the ethics approval from the University of Manchester. To assist you in reaching a decision, I have attached to this letter:

(a) **A copy of the research proposal.**
(b) **A copy of participants' information sheet explains the research step by step.**

Should you require any further information, please do not hesitate to contact my supervisor or me. Our contact details are as follows:

Dr. Andy Howes by Email: andrew.j.howes@manchester.ac.uk
Samar Albalawi by Email: samar.albalawi@postgrad.manchester.ac.uk

After the completion of the study, a report of the study result is going to be provided.

Your permission to conduct this study is greatly appreciated.

**Yours sincerely,**
Samar Albalawi

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**October 31, 2016**

Manchester Institute of Education  
School of Environment, Education & Development  
The University of Manchester  
Oxford Road  
Manchester  
M13 9PL
## Appendix 3: Data Generation Timeframe at the School

<table>
<thead>
<tr>
<th>Dates</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 2016</td>
<td>• Meeting with the head of science department in school</td>
</tr>
</tbody>
</table>
| January 2017 - February 2017 | • Meeting and introducing myself along with the data generation plan with all staff of the science department in school.  
|                        | • Attending different science classes.                               |
|                        | • Selecting the potential participants classes.                      |
|                        | • Contacting the science teachers to set date and time to introduce myself to the student. |
| March 2017             | • Distribute the survey.                                             |
|                        | • Analyse the survey data.                                           |
|                        | • Selecting the potential participants.                              |
|                        | • Gave the potential participants the assent form- photos ownership- parents authorisation form. |
|                        | • Distribute the camera and the photo guide.                         |
| April 2017 – May 2017  | • Starting Photo Elicitation Interview PEI in pair.                  |
Appendix 4: Questionnaire

Name:...........................................

What do you think about Science?

This survey asks questions about you and your interest in science. There are no right or wrong answers for the questions. We want to know what you think.

(Please tick only one box in each row)

**Q1: Learning science at school**

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) We learn interesting things in science lessons.</td>
<td>□1</td>
<td>□2</td>
<td>□3</td>
<td>□4</td>
</tr>
<tr>
<td>b) I look forwards for my science lesson.</td>
<td>□1</td>
<td>□2</td>
<td>□3</td>
<td>□4</td>
</tr>
<tr>
<td>c) Science lessons are exciting.</td>
<td>□1</td>
<td>□2</td>
<td>□3</td>
<td>□4</td>
</tr>
<tr>
<td>d) I would like to do more science at school.</td>
<td>□1</td>
<td>□2</td>
<td>□3</td>
<td>□4</td>
</tr>
<tr>
<td>e) I like science better than the other subjects at school.</td>
<td>□1</td>
<td>□2</td>
<td>□3</td>
<td>□4</td>
</tr>
<tr>
<td>f) Science is boring.</td>
<td>□1</td>
<td>□2</td>
<td>□3</td>
<td>□4</td>
</tr>
</tbody>
</table>
Q2: science outside school:

a) I would like to join a science club.

b) I like watching science programmes on TV.

c) I like to visit science museums.

d) I would like to do more science activities outside school.

e) I like reading science magazines and books.

f) It is exciting to learn new things which have happened in science.

Q3: My plan for the future:

a) I would like to study more science in the future.

b) I would like to study science at university.

c) I would like to have a job working in science.

d) I would like to become a science teacher.

e) I would like to become a scientist.

Thank you for answering all these questions!
Photo elicitation interview (PEI): using photos to elicit secondary students’ perspectives of connecting science with the real world.

My name is Samar Albalawi, and I am a doctoral student in the Institute of Education at the University of Manchester. I am working with Dr. Andy Howes on this research study. I would like to tell you about this study and ask if you will take part in it.

What is a research study?

A research study is when people like me collect a lot of information about a certain thing to find out more about it. Before you decide if you want to be in this study, it’s important for you to understand why we’re doing the research and what’s involved.

Please read this form carefully. You can discuss it with your parents or anyone else. If you have questions about this research, just ask me.

Why are we doing this study?

We are doing this study to find out how students’ like you make sense of science we learn in classroom and life outside the school, this can help middle school and high school teachers’ understand how to make science lesson more easily and effective. This study is not part of your schoolwork, and you won’t get grades on it.

Why are we talking to you about this study?

We’re asking adolescents if they would like to participate. We’re inviting you to take part because you are this age and you go to a school where we’re doing the study.
Where will this study be conducted?

This study will be in your school, during school hours.

What will happen if you are in this study?

If you agree to be in the study and your parents give permission, we will ask you to:

- Take some photos:
  
  We will give to you:
  1. Camera.
  2. Photos guide.

  We are going to ask you to take photos outside school; the photo guide will help you of what kind of photo you should take.

  Do not worry the type of photos is very simple and all about science. You don’t have to be professional for this mission.

- Be interviewed:

  We will choose a random sample (not everyone) of the students who agree to be in the study. (A random sample is like pulling numbers out of a hat or flipping a coin to decide.) We will ask these students to also participate in an interview with me or one of our researchers. If you are chosen and want to be interviewed, the researcher will meet with you in school.

  We will ask you questions about the way you study and learn, and audiotape (record what we’re saying) if you give your permission. If you say it’s okay about the taping but feel uncomfortable or change your mind, we can turn off the tape recorder or stop the interview at any time. Just let us know. The interview will take up to 30 minutes.

Are there any benefits to being in the study?

There is no benefit to you personally for taking part in this study. But we hope that the results of the research will help improve ways of learning science for students in the future.

Are there any risks or discomforts to being in the study?

- You might get bored or tired and decide that you don’t want to finish the interview. If so, just tell us that you want to stop.

- A possible risk for any research is that people outside the study might get hold of confidential study information. We will do everything we can to make sure that doesn’t happen.
Who will know about your study participation?

Besides you and your parents, the researchers are the only ones who will know the details of your study participation. If we publish reports or give talks about this research, we will only discuss group results. We will not use your name or any other personal information that would identify you. To help protect confidentiality, we will give your study data a code number, and keep it in a file with a password that only the researchers know. The file will be on a computer that only the researchers are allowed to use. We plan to keep this information for 5 years, in case we or other researchers want to use it later for other studies. But we will follow the same steps we just described to keep it as confidential as possible.

Will you get paid for being in the study?

You will not be paid for being in this study.

Do you have to be in the study?

No, you don’t. Research is something you do only if you want to. No one will get mad at you if you don’t want to be in the study. And whether you decide to participate or not, either way will have no effect on your grades at school.

Do you have any questions?

You can contact us if you have questions about the study, or if you decide you don’t want to be in the study any more. You can talk to me, or your parents, or someone else at any time during the study. My phone number is Samar Albalawi: 07490213268, or you can call Dr. Andy Howes 510-000-0000.

What if you want to complain?

If there are any issues regarding this research you should contact the researcher in the first instance Samar Albalawi by Email: samar.albalawi@postgrad.manchester.ac.uk However, if you would prefer not to discuss with members of the research team, please contact Dr. Andy Howes by Email:

If you wish to make a formal complaint about the conduct of the research you can contact a Research Governance and Integrity Manager, Research Office, Christie Building, University of Manchester, Oxford Road, Manchester, M13 9PL, by emailing: research.complaints@manchester.ac.uk or by telephoning 0161 275 2674or 275 8093

This Project Has Been Approved by the University of Manchester’s Research Ethics Committee [UREC reference number].

Thank you for your time
Appendix 6: Assent Form

If you decide to participate, and your parents agree, we'll give you a copy of this form to keep for future reference.

If you would like to be in this research study, please sign your name on the line below.

Please initial box

1. I confirm that I have read the attached information sheet on the above project and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.

2. I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving a reason and without detriment to my treatment/service/self.

3. I understand that my data will remain confidential.

4. I understand that the interviews will be audio-recorded.

5. I agree to the use of anonymous quotes.

6. I agree that any data collected may be archived and used as anonymous data as part of a secondary data analysis process.

I agree to take part in the above project

<table>
<thead>
<tr>
<th>Name of participant</th>
<th>Date</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
If you are happy to let her participate, please complete and sign the consent form below.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I confirm that I have read the attached information sheet on the above project and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.</td>
</tr>
<tr>
<td>2.</td>
<td>I understand that the participation in the study is voluntary and that she is free to withdraw at any time without giving a reason and without detriment to her study.</td>
</tr>
<tr>
<td>3.</td>
<td>I understand that the participants’ data will remain confidential</td>
</tr>
<tr>
<td>4.</td>
<td>I understand that the interviews will be audio-recorded.</td>
</tr>
<tr>
<td>5.</td>
<td>I agree to the use of anonymous quotes.</td>
</tr>
<tr>
<td>6.</td>
<td>I agree that any data collected may be archived and used as anonymous data as part of a secondary data analysis process.</td>
</tr>
</tbody>
</table>

I agree to allow my daughter take part in the above project

<table>
<thead>
<tr>
<th>Name of parent</th>
<th>Date</th>
<th>Signature</th>
</tr>
</thead>
</table>

Appendix 7: Parents Authorization
Appendix 8: Photograph Copyright Release Form

Guardian Consent For under 18:

I, ________________________________ give permission for Samar Salem Albalawi Ph.D. and Dr. Andy Howes to own, use, and publish my photographs developed during the “Photo elicitation interview (PEI): using photos to elicit secondary student perspective of connecting science with the real world” study. They are free to use the photographs for presentations and publications about this project.

I am the parent/legal guardian of the following children, and have read this release and approve of its terms in their behalf.

Printed Name of Child: ________________

Guardian Signature: ________________

Date: ____________________
Appendix 9: Participants profile

**Y9**

<table>
<thead>
<tr>
<th>Name</th>
<th>Faiza</th>
<th>Mila</th>
<th>Layla</th>
<th>Ayah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Ethnicity:</td>
<td>Other Pakistani</td>
<td>White - British</td>
<td>Other Pakistani</td>
<td>Other Pakistani</td>
</tr>
<tr>
<td>Attainment level:</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Level of interest in science:</td>
<td>She is agreed science is boring</td>
<td>She is agreed science is strongly boring,</td>
<td>She is strongly disagreed that science is boring</td>
<td>She is disagreed that science is boring.</td>
</tr>
</tbody>
</table>

**Y8 a4**

<table>
<thead>
<tr>
<th>Name</th>
<th>Ameerah</th>
<th>Tina</th>
<th>Luna</th>
<th>Eva</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Ethnicity:</td>
<td>Arab</td>
<td>Any other Black background</td>
<td>Other Asian</td>
<td>Bangladeshi</td>
</tr>
<tr>
<td>Attainment level:</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Level of interest in science:</td>
<td>She is strongly dis-agreed science is boring.</td>
<td>She is strongly dis-agreed science is boring.</td>
<td>She is strongly agreed science is boring.</td>
<td>She is strongly agreed science is boring.</td>
</tr>
</tbody>
</table>

**Y8 b2**

<table>
<thead>
<tr>
<th>Name</th>
<th>Raneem</th>
<th>Maryam</th>
<th>Emma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Ethnicity:</td>
<td>Other Pakistani</td>
<td>Bangladeshi</td>
<td>Bangladeshi</td>
</tr>
<tr>
<td>Attainment level:</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Level of interest in science:</td>
<td>She is strongly dis-agreed science is boring.</td>
<td>She is dis-agreed science is boring.</td>
<td>She is strongly dis-agreed science is boring.</td>
</tr>
</tbody>
</table>
### Y7 b3

<table>
<thead>
<tr>
<th>Name</th>
<th>Aria</th>
<th>Sophia</th>
<th>Olivia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Other Pakistani</td>
<td>Other Pakistani</td>
<td>Other Pakistani</td>
</tr>
<tr>
<td>Attainment level</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Level of interest in science</td>
<td>She is strongly disagreed science is boring.</td>
<td>Agreed science is boring.</td>
<td>Agreed science is boring.</td>
</tr>
</tbody>
</table>

### Y7 b2

<table>
<thead>
<tr>
<th>Name</th>
<th>Bella</th>
<th>Reem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Somali</td>
<td>Arab</td>
</tr>
<tr>
<td>Attainment level</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Level of interest in science</td>
<td>Agreed science is boring.</td>
<td>Strongly disagreed science is boring.</td>
</tr>
</tbody>
</table>
Please take photos of the following statements. Remember to name each photo whatever you would like.

<table>
<thead>
<tr>
<th>Take a photo from anywhere</th>
<th>What explanation would you give to this photo?</th>
</tr>
</thead>
<tbody>
<tr>
<td>... showing how you see the real world.</td>
<td></td>
</tr>
<tr>
<td>... showing how you see the real world with science in it</td>
<td></td>
</tr>
<tr>
<td>... showing science disconnected from the real world.</td>
<td></td>
</tr>
<tr>
<td>... showing a connection between science and the real world.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Take a photo in your home</th>
<th>Your explanation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>... of somewhere or something showing a connection between science and the real world</td>
<td></td>
</tr>
<tr>
<td>... of somewhere/ something that inspires you to do science.</td>
<td></td>
</tr>
</tbody>
</table>

Thank you
Appendix 12: Survey results

Q1: We learn interesting things in science lessons

<table>
<thead>
<tr>
<th>Q1</th>
<th>strongly agree</th>
<th>agree</th>
<th>disagree</th>
<th>strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>q1</td>
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<td>19</td>
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<td>0</td>
</tr>
<tr>
<td>q1</td>
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</tr>
<tr>
<td>q1</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>q1</td>
<td>16</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>q1</td>
<td>8</td>
<td>13</td>
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</tr>
<tr>
<td></td>
<td>43</td>
<td>61</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Q2: I look forwards for my science lesson

<table>
<thead>
<tr>
<th>Q2</th>
<th>strongly agree</th>
<th>agree</th>
<th>disagree</th>
<th>strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>q2</td>
<td>2</td>
<td>16</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>q2</td>
<td>11</td>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>q2</td>
<td>6</td>
<td>11</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>q2</td>
<td>9</td>
<td>10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>q2</td>
<td>6</td>
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<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>58</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

Q3: Science lessons are exciting

<table>
<thead>
<tr>
<th>Q3</th>
<th>strongly agree</th>
<th>agree</th>
<th>disagree</th>
<th>strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>q3</td>
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<td>13</td>
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</tr>
<tr>
<td>q3</td>
<td>7</td>
<td>11</td>
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<td>0</td>
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<tr>
<td>q3</td>
<td>9</td>
<td>7</td>
<td>2</td>
<td>5</td>
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<td>q3</td>
<td>12</td>
<td>5</td>
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<tr>
<td>q3</td>
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<td>2</td>
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<tr>
<td></td>
<td>37</td>
<td>45</td>
<td>17</td>
<td>7</td>
</tr>
</tbody>
</table>
Q4: I would like to do more science at school

QA: strongly disagree disagree agree strongly agree
0 10 20 30 40

Q5: I like science better than the other subjects at school

QA: strongly disagree disagree agree strongly agree
0 10 20 30 40

Q6: Science is boring.

QA: strongly disagree disagree agree strongly agree
0 10 20 30 40

Q7: I would like to join a science club

QA: strongly disagree disagree agree strongly agree
0 10 20 30 40
Q8: I like watching science programmes on TV.

<table>
<thead>
<tr>
<th></th>
<th>strongly disagree</th>
<th>disagree</th>
<th>agree</th>
<th>strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>q8</td>
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<td>2</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>q8</td>
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<td>9</td>
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<td>3</td>
</tr>
<tr>
<td>q8</td>
<td>3</td>
<td>7</td>
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<td>6</td>
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<tr>
<td>q8</td>
<td>5</td>
<td>3</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

Q9: I like to visit science museums.

<table>
<thead>
<tr>
<th></th>
<th>strongly disagree</th>
<th>disagree</th>
<th>agree</th>
<th>strongly agree</th>
</tr>
</thead>
<tbody>
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<td>q9</td>
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<td>1</td>
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<td>q9</td>
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<td>3</td>
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<td>q9</td>
<td>1</td>
<td>3</td>
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<td>2</td>
</tr>
<tr>
<td>q9</td>
<td>8</td>
<td>3</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

Q10: I would like to do more science activities outside school

<table>
<thead>
<tr>
<th></th>
<th>strongly disagree</th>
<th>disagree</th>
<th>agree</th>
<th>strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>q10</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>q10</td>
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<td>3</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>q10</td>
<td>2</td>
<td>4</td>
<td>11</td>
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</table>

Q11: I like reading science magazines and books.

<table>
<thead>
<tr>
<th></th>
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<td>q11</td>
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<td>q11</td>
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<tr>
<td>q11</td>
<td>6</td>
<td>9</td>
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<tr>
<td>q11</td>
<td>12</td>
<td>28</td>
<td>40</td>
<td>28</td>
</tr>
</tbody>
</table>
Q12: It is exciting to learn new things which have happened in science.

<table>
<thead>
<tr>
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<th>agree</th>
<th>disagree</th>
<th>strongly disagree</th>
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</thead>
<tbody>
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<td>Q12</td>
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<td>14</td>
<td>3</td>
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<td>Q12</td>
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<td>Q12</td>
<td>10</td>
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<tr>
<td>Q12</td>
<td>16</td>
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<tr>
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<td></td>
<td>53</td>
<td>39</td>
<td>9</td>
<td>6</td>
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</table>

Q13: I would like to study more science in the future.

<table>
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</thead>
<tbody>
<tr>
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<tr>
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<tr>
<td></td>
<td>38</td>
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Q14: I would like to study science at university.

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<thead>
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<th>strongly disagree</th>
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</table>

Q15: I would like to have a job working in science.

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<thead>
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<th>disagree</th>
<th>strongly disagree</th>
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</table>
Q16: I would like to become a science teacher

<table>
<thead>
<tr>
<th>Q16 be Science teacher</th>
<th>strongly agree</th>
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<th>disagree</th>
<th>strongly disagree</th>
</tr>
</thead>
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<td>q16</td>
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<td>q16</td>
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<td></td>
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<td>35</td>
<td>36</td>
</tr>
</tbody>
</table>

Q17: I would like to become a scientist

<table>
<thead>
<tr>
<th>Q17 be Scientist</th>
<th>strongly agree</th>
<th>agree</th>
<th>disagree</th>
<th>strongly disagree</th>
</tr>
</thead>
<tbody>
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<td>37</td>
<td>28</td>
</tr>
</tbody>
</table>
Appendix 13: Example of participants full interview

<table>
<thead>
<tr>
<th>Luna Y8</th>
<th>Other Asian, Urdu</th>
</tr>
</thead>
<tbody>
<tr>
<td>She is strongly agreed that science is boring, and strongly disagreed that science lesson is exciting or to be science teacher.</td>
<td></td>
</tr>
</tbody>
</table>

**Which photo you would like to begin with?**

The statement was **No.1 Showing how you see the real world.**

![Photo 1](image1)

**why you chose this photo to begin with?**

because as you can see you are in the real place, you are not dreaming or something or something.

She points to the sky on the photo so I said, so the sky for you is the real world.

Yaah, it is for me showing me that I am alive.

**No.2 Showing how you see the real world with science in it.**

![Photo 2](image2)

She wrote in the paper that Plant growing, and explain it to me:

Science is flower and flower related to science, and flower also in the real world.

**what makes flowers related to science?**

like photosynthesis.

**is that mean the plant is the real world too?**
<table>
<thead>
<tr>
<th>Statement</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yea, No. I do not know.</td>
<td></td>
</tr>
<tr>
<td>she wasn't sure if the plant or the flower is part of the real world or no.</td>
<td></td>
</tr>
<tr>
<td>This is the real world, what is this? The ground. The ground is the real world?</td>
<td>I took a picture of that because, in the real world there are plants and this a growing plant. this plant is related to the science, but plant not in the science they are in the real world, they live in the real world. The plants related to science BUT NOT IN science.</td>
</tr>
<tr>
<td>I noticed that the participants deal with each statement separately, they don't make any connections. Or how is every thing is related to another which is maybe explain why they lack of make connection between the real world and science.</td>
<td></td>
</tr>
<tr>
<td>بالنسبه لي اذا كان عمل بسيط كذا او واجب بهذه البساطة لا يمكنهم انجازه و عمل ربط بين ماهية العالم الحقيقي و العلوم. اذا كان في الخانة الاخرى تلورقة المرفقه عمله او اشارات ما يعني او قد يساعد في ذلك الربط و الطلاب لستخدمونه او يتبناها. فهذا معناه انه هناك مشكلة حقيقية في رابط العلوم بالميجا اليومية و ان جميع هذه الارامل التباقات لا تركز فيها لكن الان مع 8 ولا زالوا الربط لديهم غير موجود.</td>
<td></td>
</tr>
<tr>
<td>ok, so you said at the first picture that the sky is the real world, and now for the second picture you said the ground and plant are the real world. what is the real world you mean? could you please explain it to me?</td>
<td></td>
</tr>
<tr>
<td>i don't know i am confusing now. that is fine, no problem let's move on.</td>
<td></td>
</tr>
<tr>
<td>Luna doesn't know what is the real world, she cant decide and defined the real world.</td>
<td></td>
</tr>
<tr>
<td>ok pick the third photo. which one you would like? For the third statement: … No.3 Showing science disconnected from the real world?</td>
<td></td>
</tr>
</tbody>
</table>
why you taken this photo?

This said disconnection between the science and the real world. Because this is something human made in the real world not in science.

So, this not connecting to the real world?

Yea.

So, the real world was sky in the first photo, and now in the second one is the ground? So, is that mean the ground and the sky is the real world too?

Yea

then I asked why you taken this photo?
this is form home for the statement...

No.6 from home of someone /something inspired you to do science.

Why this is inspired you to do science?

Because like plants, and this is telling me if I liked the plants science tell I can search about the plants. this is something at home, like my mom really likes the plants. it is a real plant, she always takes care of them, so when I saw her makes me think why and how those plant born older. make me really want to search about that.
No.5 from home of somewhere or something showing a connection between science and the real world.

| this is a flower like in the real world. But they are not a real flower they are fake flower. they also made by human, decoration for by the flower human inspired by the real flower. |
| If it wasn’t plant in the real world, so they wouldn't know about the plant or the flower all that mean. So the make it fake so it will stay for longer. For decoration like that at home. |
| the connection here was who the science inspired human to do the fake flower. |
| The statement No. 2 with science in it THE PLANT+4 confused the girls. |
| This is the same but this about flower and this about plant. |
| **So for showing the connection between science and the real world.** in the real world like you can see the tree like where we are living in the plant earth. there is flower. Animals a lot of thing are related to the science. I think the real world is made of science like food and experiments all that, like when we are in house there scientist already know about science and start from science make those things. |
| **Before we finished I asked Luna to explain to me more about science and the real world. I mentioned the photo number 2.** |
| Its seems this like I said there is first more thing like we first born small and the grown bigger and bigger also plants are the same the first small the they grown to be very big. Like the circle of the flower the plants as same as ours. like first we are |
young then big the we die one die. if we did not eat we die like the plants if they didn't have water they die as well. like this important to care about living things human like us. For that I chose this one but as well I don’t know how to explain it.

وعدت زويا اعطيها الصور لانه قالت هذه اول مرة تلتقط صور و تبي تحفظ فيها.

**Ameerah Y8**
She got 2 out of 5.
She disagreed that science is better than other subject or be a science teacher in future.
Otherwise all her choice is agreed.

Samar: which photo you would like to begin with? and why?

<table>
<thead>
<tr>
<th>No.1 Showing how you see the real world.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image-url" alt="Image" /></td>
</tr>
<tr>
<td>Ameerah: i will start with the real world, I think this is the real world. Because the blue and green is like the earth and the earth the real world has river, trees and animals. that is what I think.</td>
</tr>
<tr>
<td>the trees and the skies makes the earth colour and the earth has the real world with the river and trees and animals and people.</td>
</tr>
<tr>
<td>the number 2</td>
</tr>
<tr>
<td>Showing who the real world with science with it.</td>
</tr>
</tbody>
</table>
Ameerah: I took this picture near my house, I took this pic cuz the electricity is science and the real world as I said is green and blue like the earth. and the electricity comes like science for example when we use the electricity for the cars, homes and like other countries. the green trees they gave you paper and for science recycle for science

Remember to have look again for the units.

so I think that the trees could be for science and for the real world as well. When they gave you trees papers you recycle the paper with the right bins.

Samar: so, you think this is present the connection between the science and the real word.

Ameerah: yes, the electricity and recycling.

No.3 showing science disconnected from the real world.

Ameerah: okay, this the food label, cuz food label not really connected to the earth. food label is like food has a label talking about fat
and weight and information. that is what i think they are not together they are different. Cuz this one talk about food. The real world talk about human, rivers, animals, trees , air. but this one just like food.

so the food label from science and different from the real world which the real world is air, life. the food label just the food that we eat.

she took a photo for the trees with the train station and said the electricity in here the science and the trees is the real world.

No.4 showing the connection between the science and the real world.

she thinks that number 2+4 the same.

Ameerah: okay, the real world is neuter and as we said science is the trees give you paper, if the leaves gives you paper so recycling and the real world is the neuter. and i thought the flower cuz we believe in Allah and how he brought the flower and makes them shine and beautiful.

It could be about the cell plants how the cell planets how to make the leaves green and who to keep the leaves grown that science.

N.5 something or somewhere showing the connection between science and the real world from your home.
Ameerah: this from my neighbour garden, i took that picture because the leaves that grown up is nice and beautiful and could be connected by science and the real world by like the real world blue and green and science some plants, recycling and like who to grown them up or some thing like the food. science could be connected by the food like the real world.

N.6 something or somewhere inspired you to do science

she does not take photo for this one.

Ameerah: science inspired me because in the future i want to be dentist and in science we do like experiments and we learn about how neuter grows and like we talk about the real world, we talked about how to be that like who the people do grown the trees , food grows and anything they want. that is way inspired me to do science and i love science too much.

Yea so in future i wanna be a dentist and the science will help me a lot in future.

Picture for the moon: connection

I took this pic i though about the real world and science tells how Mars and plants comes .

the moon is science.

At the end you think the real world is the neuter, yes i think the real world is the earth that bring out the river, animals and humans.

Science i think is about the electricity ,when you do experiments to find out something like say you want know who they grown the trees, you gonna do some experiments to find out research like university doing research and research to find the thing that they want to find out.
Raneem Y8

No. 1 showing how you see the real world.

Raneem: Cuz in the real world your life like a book, so you have a beginning and problem and the end.

Samar: What kind of problem we have?
Raneem: for example, some people might have bulled so they have to faced that and try to grow up.

Samar: what is the beginning of our life? And the end?
R: when we are born, when we died.

No. 2 showing how you see the real world with science in it.

R: plants, plants a live and they have cells. The life style is similar to us.
S: what is science in the plants?
R: animals they eat these plants which contain sugar in them, and then give energy to the animals. So, this sound to me science.

S: what is science in the plants?
R: first they are like seeds and when you put water is starting to grow so as grows more feature come like for example that meant be a flower. So first it all plants and as grows grow leaves and then a brow a flower.

**No.3 showing science disconnected from the real world.**

Aliens
R: cuz we do not know if they exist or no, so science is still finding out if they exist.

S: in which way they disconnect to the real world?
R: cuz we think about it we like to make up this creature but we don't know if it is real.

**No.4 showing the connection between science and the real world.**

Fire 5:04

R: it is gives of heat and this is how the earth gets heat. Some beens they go to the earth cuzing the pollution some of them, and when the beans stay the earth gets warmer.

S: What is the science in this photo?
R: when some beans reach the earth the gas and the pollution hold in it back cuz more heat so the ice in Atlantic effects.
S: have you read about global warming? Or studying?
R: we done it last year.

**No.6 something inspired you to do science?**

The periodic table

R: it has a lot of elements and chemicals forms and it is really looks very scientific.
S: in which way inspired you to do science?
R: like we look at it, can you see science in it for example if like coal, you don't know what is coal made out it. it is a metal like iron we have it in food as well as metal.
S: so you inspired to do science to find out more?
R: Yea.

**No.5 of something or somewhere showing connection between science and the real world at Home.**

Spinne

R: when you spin it that physics on it, so when spin it you can see that is turning cuz the gravity and like in future this can be more developed.

S: are you going to do something in future related to science?
R: yea. I wanna be a doctor. Yea my mum family doctors. Grandparents a doctor. My grandma she was a surgeon. My mum not working. Yea I got interest.

S: do you do any activities related to science outside school?
R: revising.
R: no nothing

S: have you seen any documentary or been to any museum?
R: yea, I've seen a documentary about animals like where they lived.

S: do you think science we do at school is similar or related to everyday life?
R: Yea cuz it is gives an information so for example like radiation, like when something gives us heat. For example if you wear this cloths in summer you feel more warmer. Like in summer what think you should wear.

S: if you are a science teacher what do you do in science classes?
R: the same thing. More experiments. I don't think science is boring and I enjoy science.

S: do you remember science from the primary school?
R: we don't did science in the primary school.

S: when did you find your self enjoy science?
R: when we do practical and experiments. In high school.

S: what kind of topic you like?
R: I like chemistry.

S: which topic so far you enjoyed now?
R: light and sound.
In science you can compare your eyes to the camera and the sound like what you can hear compare to the animals how we can hear compare to them.

Maryam
Bangladeshi

strongly disagreed to do more science at school, or working in job including science. She was disagreed to do science in future.

Which photo you would like to start with?
**No.2 showing how you see the real world with science in it?**

Maryam: I want to start with this one, … the real world to me is more like about the nature and more about natural stuff and having a car is part of every day life, so you drive it is like an invention so is part of science, so together is like my real world with science in it.

Samar: so in this photo the science is the car and what is the real world?
Maryam: the trees and outside.

Samar: what did you take for
**No.1 .. showing how you see the real world.**
Maryam: cuz the real world include the house this is part of our life so, and has nature in it and we live in it like your real world.

the real world is where you live, your environment so like houses.

**No.3 ... showing science disconnected from the real world.**

M: I tried to get the picture for just the sky and this came in it. the sky what i meant is present the space and stuff, this like the base of the world. It has nothing no manmade in it and stuff. it is like part of the real world and the space is part of the world. the world within the space.

S: so this is not connected to anything in science.

**No.4 ... showing a connection between science and the real world.**
M: I took this one cuz has the wires and the houses which is showing the real world. we use the Internet everyday and the electricity and this like if you went home and there is no Internet, no light and everything you like cuz this how you live your life and you need the electricity, so this science with the real world in it.

No.5 … in your home, something or somewhere showing a connection between science and the real world.

M: I got this one because the car again this just like the part of the real world and science in the car and how car constructed and stuff it is just related to your real world. that is in the world and that is in science. and that is makes it part of the real world.
M: I took this one cuz it is how nature how it is made and why it is made, i just want to find out like how human developing and changing one the time and how the world changing over time and like just nature how is made, different species and stuff i found it is really interesting.

S: if you are a teacher what would you change in science?
M: I would like really change thing that not important like, my be i get things that we really need to know like space and just the part of every day life like who we live and stuff, so we need like to explore those part more than in practical.

S: what topics you like in science and you think it is interested and you enjoy it?
M: know more about nature and how is trees fall and stuff, how they helped us live.

S: do you have any topic you think you need to know more?
M: what we learning it is important like separation and stuff, I think as we go along we learn more and figure more stuff out.

S: if you are able to change something in class room what would be? Suggestion?
M: instead of talking about it, do this and that, the best way to show us. do more practical things.

S: do you remember the first time you know this science? in primary school for example?
M: in primary school, we didn't do acutely science we did what in subject but we don't really do science. we just did the basic subject.

S: what do you think make science boring?
M: sometimes, just like talking, i don't know I like doing more practical stuff like cuz it gets in my head easier, when go to that subject just comes in your head and you know this is happened.
Appendix 14: First data analysis manually at my study room wall
Appendix 15: The Pilot study

Samantha, 14 years old.

Samantha took a photo for her father as an answer to the statement: 1- Take a photo of somewhere/something that inspires you to do science.

She said, “I pick dad because he is a scientist, he is so cleaver.”

2- Take a photo showing how you see the real world.
She took a photograph of leaves, and explained, “I pick the leaves for showing how I see the real world because it’s grown and it’s living. They grow and not manmade and don’t need very much science.” This revealed that Olivia, from her perspective, understands that science is manmade and manmade is not the real world. The real world for her, as she said, was everything from Mother Nature such as trees and animals. She supported this view when she answered the statement:

3- Take a photo showing how you see the real world with science in it.

She took a photo of a car, and later said, “I chose a photo of a car because it’s manmade and you need science in the car more than you need on leaves.”

Taking a photo of her Cat was the answer for this statement:
4- Take a photo of something showing a connection between science and the real world.
Samantha later said, “She [the cat] is living and she is real basically, biologic science.” As mentioned above, she classified the animal as being from the real world, but the physiology as the science. After that she was asked: Do you think science classes are related to the real world? “Not really sure, there is a lot of chemical we do, but not in practical ways, even when we are in practical room. We don’t know where is the chemical come from, they come from underground or they come from evaporation how did the scientists find about that I really want know about it”.
