Attitudinal factors affecting the choice of learners of different ages to study Mathematics in post-compulsory education in the context of England

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ABSTRACT

This thesis explores the issue of learners' attitudes towards mathematics in three dimensions: mathematical self-concept, vision of mathematics, and the affective dimension. Mathematical self-identity and normative influences are also explored. The impact of these components on the decision of learners to study mathematics when they are no longer required to do so is examined, and conclusions drawn about the dominance of each attitudinal factor. The study takes a cross-sectional approach, and explores changes in attitude to mathematics as children grow up. This study utilizes multiple methods by gathering quantitative data using Likert-style questionnaires, and supporting evidence with qualitative data from individual semi-structured interviews. This study provides some answers as to what the attitudes of learners in England are towards mathematics, and how these attitudes differ between students of different ages. The questionnaire data provides statistical insight into learners' thoughts, feelings about and perceptions of mathematics, whilst the qualitative interview data provides reasons why learners feel as they do. The key findings of the research were that a student's mathematical self-concept is key to the decision to study mathematics at post-16 level, and that self-concept appears to deteriorate over time. Almost of equal importance was students' perceptions of how useful mathematics would be for their chosen careers, which again appear to wane as students become older.

Whilst this particular study is anchored to the context of England, the theoretical framework, methodology and subsequent findings have implications for the global context of mathematics education. The focus of this thesis is largely upon how attitude develops and students' subsequent dispositions to choose post-compulsory mathematics change over time; but there is a compelling body of evidence to suggest that the attitudinal factors explored here have a significant impact upon mathematical performance. This thesis provides a new framework for examining attitude towards mathematics by combining three dimensions of attitude towards mathematics with the subjective norm, and the Theory of Planned Behaviour. Whilst these theoretical notions are used in this thesis to understand the actions of learners in England, they are applicable to the study of this field in the global context of mathematics education. They are also arguably impactful upon policy in England; in terms of teaching, examination and classroom organisation. The use of this theoretical framework combined with a research methodology which is standardised across the cross-sections of participants fills the gap in the current knowledge of how attitudes towards mathematics develop in learners as they progress through their education.

Contents

List of Tables

List of accompanying material

1. Ethics forms
2. Online Questionnaire Questions
3. Participant information sheets
4. Semi-Structured Interview Schedule
5. Codebooks for interview responses
6. Content of mathematics lessons for students at Key Stages One and Two

Academic Thesis: Declaration Of Authorship

I, Claire Walker

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

Attitudinal factors affecting the choice of learners of different ages to study Mathematics in post-compulsory education in the context of England

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Either none of this work has been published before submission, or parts of this work have been published as: [please list references below]:

Signed:

Date:

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But mostly, this is for Jim. You supported me when I was ready to give up. You made me brave enough.

Ms Walker

Definitions and Abbreviations

In the following section I identify the key terms and acronyms used throughout the thesis.

Key Stages: Blocks of school year groups into which the National Curriculum in England is organised

EYFS: Early Years and Foundation stages, although this stage can include pre-school aged children aged between 3 and 4 years, any Early Years students referred to in this study are aged 4 to 5.

Key Stage One: English school years 1-2, students in this Key Stage are typically aged between 5 and 7 years old

Key Stage Two: English school years 3-6, students in this Key Stage can be expected to be aged between 7 and 11 years old

Key Stage Three: English school years 7-9, although in some schools this Key Stage is truncated to years 7-8. Students in this year group are generally aged 11 to 14 years

Key Stage Four: English school year groups typically 10-11, students in this stage are aged between 14 and 16 years

Sixth Form: English school years 12-13. Students enter sixth form following their GCSE examinations in order to study A-Levels, or vocational equivalents. This is sometimes referred to as Key Stage Five.

GCSE: General Certificate of Secondary Education. These are examined subjects studied by students in Key Stage Four. Whilst students are required to study some mandatory subjects (Mathematics, English Language and Literature, and Science) they also study optional subjects (for example Drama, Art, Geography and History)

AS-Level: AS Levels are completed during the first year of Sixth Form. They are taken as a standalone qualification. This was a curriculum change in 2016, prior to this they formed the first half of the A-Level qualification.

A-Level examination: These are examinations taken at the end of Year 13, prior to students leaving Sixth Form College. A-Levels are the required standard for university entrance (although some students will take equivalent vocational courses)

Destination data: Data received by schools in counties where an attached sixth form is not typical. This data informs schools as to which AS and A2 Levels students have opted to study at sixth form college.

CATS: Cognitive Ability Tests. These are taken by Year 7 students on entry to secondary school. Students participate in three tests: verbal reasoning, non-verbal reasoning and quantitative reasoning. The scores of these tests, together with an average score of the three, are used as an indicator of a student's aptitude in these areas as they progress through their secondary school education.

Terminal Examinations: These are the final public exams taken by students at the end of Key Stages Four and Five. Prior to 2016, qualifications comprised in some instances of modular exams that could be taken at any point in the course, as well as some coursework components in some instances. Since 2016, only terminal examinations count towards the final qualification, with some limited coursework in some subjects such as design technology.

Feeder Schools: Schools from which students arrive from the previous Key Stage, for example an Infant School would be the feeder school of a Junior School, and a Junior School would be the feeder School of a Secondary School. Secondary schools can have a number of feeder junior schools in the locality. This is not generally the case with junior schools, who for the most part have an attached infants school. Secondary Schools have a number of feeder junior schools, this is described as a pyramid.

Chapter One - Introduction and overview

1.1 Overview

In this chapter I begin with a statement of the research problem, and introduce the theoretical concepts key to understanding the research presented in this thesis. I also discuss some of the key related literature, and the gap in this existing knowledge that I seek to fill with the research presented in my thesis. I conclude with a presentation of my research questions.

1.2 Personal justification for embarking on this study

I am a secondary school computer science teacher and Head of ICT, and as such am interested in the current body of knowledge pertaining to STEM education. I am interested in why students might not wish to study STEM subjects in the proportions that are desirable according to both the government in England and to researchers. I am also a member of the extended senior leadership team in my institution, responsible for continued professional development and whole staff evidence-based practice, including leading all members of staff in personal action research projects designed to improve practice. As a result of this professional interest, my personal interest in educational research and the contribution of teacher-researchers to the knowledge base in this field is ever increasing. This thesis began from a personal interest in why students might not want to opt for mathematically-based STEM subjects like mine in some institutions, but has grown into a much wider interest into how theory translates into both practice and policy. It has also provided exceptional continued professional development for me personally, as I now have a much deeper and wider understanding of how the current research that impacts upon students so deeply is conducted.

1.3 Statement of the research problem

It is argued that the study of mathematics, amongst other STEM (Science, Technology and Mathematics) subjects is critical to the growth of the UK economy, and has been shown to increase future earning potential for those who choose to continue in their studies of mathematics (Noyes and Sealey, 2012). Smith (2004) claims that it is vital that society recognises the importance of mathematics both as an intellectual discipline, and of being as central importance to providing a supply of people with STEM knowledge. It is important then, for students to have the skills necessary to build the UK economy, and for that to be possible they need to study mathematics to an advanced level. Smith (2004) also makes the point that mathematics provides individuals with skills for life, and for virtually all levels of employment. In order for students to develop these skills, it is necessary for them to see the value in mathematics, and to be confident in their own abilities. The Program for

International Student Assessment (PISA) (Organisation for Economic Cooperation and Development (OECD), 2013) results show that in order to fulfill their potential, students need drive, motivation and self-confidence, but too many lack large enough quantities of the attributes to succeed. In spite of the compelling argument presented by the English Government that further study of mathematics is beneficial for individuals and for the development of the UK economically (DfE 2014, DfE 2015), corroborated by researchers (Epstein et al 2010; Noyes and Sealey 2012, Smith 2010), the uptake of mathematics by students in England entering post-compulsory education remains comparatively low. In 2014 Education Minister Nick Gibb lamented that “Only a fifth of pupils in England continue to study mathematics at any level after achieving a GCSE - the lowest of 24 developed countries” (Department for Education and Gibb, 2014). In 2013, 20 per cent of students who attained at least grade C GCSE mathematics went onto attain AS or A-level maths qualifications (DfE 2013).

In order to understand the potential causes of the arguably limited uptake of post-compulsory mathematics by students in England, it is necessary to examine and understand how learners feel about mathematics as a discipline, and their attitudes towards its continued study. A fairly wide exploratory body of knowledge exists on the attitudes of students towards mathematics. Some of this focuses upon the relationship between mathematics teaching methodologies and their impact upon student attitudes (e.g. Bergem 2016, Boaler 1997), with some of the work focusing upon the impact that teaching methodologies might have on the desire of students to pursue post-compulsory mathematics (e.g. Boaler and Greeno, 2007). Some studies focus upon how students construct an understanding of themselves as a mathematical (or non-mathematical) person (Mendick et al 2007,Walls 2009), whilst a body of knowledge focuses somewhat upon students’ perceptions of the utility of mathematics both for their lives after school (e.g. Black et al, 2009) and their perceptions on the everyday use values of mathematics (Epstein et al, 2010), which includes some of the differences in perceptions between those who choose to study post-compulsory mathematics and those who don’t. Some studies examine the perceptions of primary school students (Ashby 2009, Borthwick 2011, Dowker 2012,) whilst the majority focus upon older students. Because the attitudinal foci of these studies are so diverse, and are not all compared in one study to determine the most dominant factor, it is not possible to ascertain which of the components of attitude has the most impact on a student’s desire to study post-16 mathematics. Equally, because there is no one study based in England (although Wall’s 2009 study based in Australia goes some way to exploring how some of the attitudinal factors identified in the literature review develop over time) that uses a cross-sectional or longitudinal methodology to compare how attitudes develop as students move through their educations, it is not possible at the moment to know how students build their attitudes and perceptions of mathematics and themselves over time.

The research problem presented here is that some students, in spite of evidence that participating in post-compulsory mathematics is beneficial both to them and to the nation, do not display the desire to study advanced mathematics in the numbers desired by the English government, whether some factors are more dominant than others in making their decisions, and whether the attitudes that students have towards mathematics are fixed up until the point of making their A-Level choices, or whether they develop over time.

1.4 Statement of the research aims and contribution to knowledge

This research examines the changing attitudes towards mathematics of students in the English school system as they make their way through their compulsory education. The study examines the attitudes towards aspects of learning mathematics of students in four key stages. At Key Stage One the participants were in Year 2, at Key Stage Two they were in Years 4 and 6, at Key Stage Three in Year 7, and at Key Stage Four in Years 9 and 11 respectively. It draws comparisons and highlights the differences in students' thoughts, feelings, likes and dislikes of mathematics. In the following chapters the research aims to demonstrate whether students' attitudes change throughout their schooling, resulting in the attitudes they have at the point at which they make their choice regarding which subjects they will continue to study in post-compulsory education. The second research aim is to demonstrate the attitudes displayed both by those students who opt to study post-compulsory Mathematics, and those who do not.

The unique contribution to knowledge made with the following research, is to define which attitudes and values are exhibited both by those students who opt to study post-compulsory Mathematics, and those who do not, and to illustrate how those attitudes develop as students progress through their mathematical education. This necessitates some development of theory in terms of what constitutes 'Attitude towards mathematics' precisely and how this might impact upon decision making, as explained below and in detail in chapter three.

1.5 The context of this thesis

Whist ideas explored in this thesis have implications across other contexts globally; the study conducted here is set in the context of schools in England.

In England, the basic school curriculum is a set of subjects and standards applied across all government maintained schools, so that students learn the same content, and are assessed using the same measures. It is divided into blocks of years called 'Key Stages'. The first of these key stages is Key Stage One (school years 1-2), studied by children who may have already studied the Early Years and Foundation Stage curriculum (EYFS), entering school at the age of five, until they are seven. Children then progress to Key Stage Two (school years 3-6) at the age of seven. This is the longest key stage, completed by children at the age of eleven when they are ready to move to secondary school. Children begin Key Stage Three at the age of 11 when they enter secondary school, and complete Key Stage Three at the age of 14 (School years 7-9, although KS3 may be compressed in some schools into years 7 and 8). At the age of 14 in most schools, learners begin the final key stage of compulsory education, key stage four (years 10-11). English, Mathematics and Science are compulsory for all students, at every key stage, as well as physical education and computing. Other 'entitlement' subjects must also be studied, for example the arts from Key Stages One to Three, and citizenship in Key Stages Three and Four (DfE, 2013).

Assessment of pupil progress differs at each key stage. At the time of writing, assessment at all key stages was subject to government overhaul (DfE, 2014). The assessments described are statutory as of September 2014. Students sit a short baseline assessment at Key Stage One on entry to infant school. At the end of Year One, they sit a phonics assessment, and then at the end of Key Stage One they sit externally set, but internally marked assessments in mathematics, reading and writing, with a teacher assessment of speaking, listening and science. At the end of Key Stage Two, all students sit national externally set and marked tests in mathematics, reading, grammar, punctuation and spelling. Progress at Key Stage Three is measured since September 2014 by teacher assessment against a list of skills provided by The Department for Education. There are no pre-defined numerical levels; instead schools are free to design their own progress measures to track pupil attainment for reporting to external bodies (Df E, 2014).

In England, students complete their compulsory schooling at 18, after students take their General Certificate of Education examinations (GCSEs), and have worked towards academic A-Levels, vocational courses or employment-based training such as an apprenticeship. If they complete these with 5 or more higher grades, they have access to a wide range of further educational opportunities (Noyes and Sealey, 2012). The 40% who take this academic route typically specialize in four subjects in the first year, and continue three of these into the second (A2) year of their 16-18 studies (Smith, 2010). A-levels are the widely accepted standard qualification for university entrance in England (Noyes, 2009). A-Level in Mathematics is a pre-requisite for most STEM subjects at English universities.

1.6 Key Theoretical Concepts

In this thesis, the changing nature of students' attitudes towards mathematics is explored through bringing together the components of attitude as defined in Di Martino and Zan's work (2009, 2011) together with the sociological notion of the subjective norm (Armitage and Connor, 2001, Azjen, 1991) and the Theories of Reasoned Action (Azjen and Fishbein, 1975) and Planned Behaviour (Azjen, 1991). For this reason, the following section has been divided into three subsections, with each providing a brief discussion of one of these three areas.

1.6.1 Components of Attitude

In order to make sense of the complex range of thoughts, emotions, feelings and values that compel students in their decisions to study Mathematics at A Level (A-Levels, amongst other more vocational courses, are the first set of subjects from which learners in England can choose to study during their post-16 education), it is first necessary to define and understand the concept of attitude. This concept is discussed briefly in this section and in more depth in the later Theoretical Framework chapter. In their study 'Me and Maths' Di Martino and Zan (2009) explored 'attitude' by asking students to tell their own story with mathematics through an autobiographical essay. The components identified were: vision of mathematics, mathematical self-concept, and emotional response towards mathematics. These components of attitude are used in this thesis to inform the research design, with questions on each of these areas included in the data collection methods (questionnaires and semi-structured interviews), and these areas are used as a lens to conduct analysis of interview data. The three components are discussed in significantly more detail in the 'Theoretical Framework' chapter.

1.6.2 Subjective norm

The subjective norm is a global perception of social pressure either to comply with the wishes of others or not (Armitage and Conner, 2001). Normative beliefs are those influenced by the people in an individual's life who are important to them at a given time (Azjen, 1991), so dominant subjective norms (the person or people who might be exerting the influence) for students at the point of opting for A Level subjects might be parents, teachers and friends, or they could be completely external influences such as a TV show or film that has captured a child's attention. As explained in the section below, the subjective norm is potentially an influence upon planned future behaviour. The notion of the subjective norm is used similarly in this thesis to the components of attitude towards mathematics; both to inform research design, and as a lens for analysis of interview findings.

1.6.3 The Theory of Reasoned Action and the Theory of Planned Behaviour

The Theory of Reasoned Action and the Theory of Planned Behaviour are social psychology constructs to which this research is directly related. Azjen and Fishbein's (1975) Theory of Reasoned Action (TRA) is that a person's behaviour, in the case of this research the intention to study Mathematics at A Level, is directly influenced by a number of factors. The first is a person's attitude towards emitting the behaviour. Attitude is assumed by Azjen and Fishbein to be a similar construct to that of Di Martino and Zan, assuming it to be the person's idea of what the outcome of emitting the behaviour might be. In the instance of this research it could be, for example, "Maths might help me get to university", or "I might not get as good a grade in maths A Level as I might get in English". The second component identified by Azjen and Fishbein is the subjective norm, and the theory supposes that normative influences are likely to affect an individual's intention to perform a behaviour. The more favourable the attitude of the individual based on these components, the more likely the individual is to intend to perform the action. The theory was developed by Azjen (1991) to include the individual's perceived behavioural control (PBC) over their ability to perform the action successfully. In the instance of this research, this is comparable to the self-concept component of attitude, meaning the individual's notion of whether they would successfully complete their AS Level mathematics course to the required standard.

1.7 Relation of research to existing literature

This research relates to existing evidence in the areas of both mathematics education and psychology. In order for this thesis to be successful in addressing the research problem, it is first necessary to understand the research questions in relation to these areas, and the particular gaps in these areas of knowledge which I seek to address with my research.

A fairly sizeable body of research into students' attitudes towards mathematics exists which examines the attitudes of students of sixth form age towards mathematics (e.g. Black et al, 2009, Noyes and Sealey, 2012, Hernandez-Martinez et al, 2008). These studies examine the attitudes of students towards learning mathematics in Year 12, examining components such as the exchange value of mathematics, with students considering their next steps and how useful mathematics might be for them in the future. Also examined is the attrition in numbers of students studying mathematics following their AS-Level examinations at the end of Year 12 (which in 2012 comprised the first half of an A Level, or a standalone qualification. Since then, a curriculum change has meant that students must sit terminal examinations at the end of their two year course, when historically they sat half of these at the end of their first year), when students consider whether to complete their courses in order to attain a whole A-Level. Whilst the examination system has changed, this research still remains relevant since students could if they wanted opt for a standalone AS-Level examination.

The body of literature regarding the attitudes towards mathematics of students in secondary school appears to be smaller than that regarding those in their sixth form years, or those in

Key Stages One and Two. Students in secondary school are not ignored in the current research, although the existing literature has some short comings if it were to be used for identifying why students may or may not wish to continue studying mathematics at AS Level. Brown et al (2007) and The Royal Society (2008) examine the 'vision of mathematics' component of attitude, identifying that students on occasion felt that maths was 'boring and isolating', through interviews and large-scale questionnaire respectively. However, other components of attitude were not examined in this particular research; for example it is probably possible to find mathematics an isolated experience, but to see the exchange value in it for one's later life.

Whilst these studies have taken place, their methodologies and research questions are too diverse to draw conclusions about how and when students develop the attitudes towards mathematics displayed at the point of choosing A-Level options, which is the specific niche that this research seeks to address. Whilst there are a number studies (Black et al, 2009, Brown et al, 2007, Noyes and Sealey, 2012) regarding (at least partially in some instances) the attitudes of students towards learning mathematics in schools in England, there is no one study which examines the particular aspects of attitude which might affect A-level choices, or how these attitudes develop over time, drawing no comparisons with the thoughts and feeling of students about their mathematics education with either the previous or following key stages. The second notable limitation with literature reviewed (Black et al, 2009, Brown et al, 2007, Noyes and Sealey, 2012, Borthwick, 2011, Ruffell et al, 1998) is that the definition of attitude assumed is not common across all of the studies discussed in detail in the literature review.

The specific gaps identified in the literature will be addressed in this thesis by the use of:

- A monodimensional set of comparable data collection methods utilised across all participants from all key stages
- One single definition of attitude used to inform data collection across all key stages
- A cross-sectional methodology using stratified sampling to capture the changing dispositions towards studying mathematics at school of students across key stages
- Direct comparisons of the changing values and dispositions between students in different key stages
- Explicit analysis of attitudes and dispositions correlated directly with the intention to study or not to study post-compulsory mathematics
- Analysis of the influence that each of the components of attitude have upon the intention to study, or not study post-compulsory mathematics

1.8 Justification of research topic

This research examines how English students' attitudes towards learning Mathematics change over the time between Year 2 at the end of Key Stage One, and Year 11, when students make their final decisions as to which subjects they will continue to study during Year 12.

Since there is an agreement across researchers regarding the changing nature of attitude (McLeod 1992, Hogg and Vaughan 2011), it appears that attitudes are not always stable over time. It is perhaps worthwhile then, to assume that school students might not finish Secondary education with the same attitude towards mathematics with which they started Primary school. This premise suggests that a longitudinal or cross-sectional study of how attitudes change over time might help to pinpoint events in students' mathematical education that are key to forming their attitude toward mathematics at the end of Secondary education, the point at which they will make the decision as to whether or not to continue to study mathematics after they finish compulsory education.

1.9 Research questions

The research questions addressed in the thesis are:

1. Do the attitudes of school students towards mathematics differ at different ages, and if so, how?

2a. 'What are the factors which affect a student's attitude towards choosing to study Mathematics in post-compulsory education?'

2b. 'Which of these are the most dominant?'

1.10 Thesis overview

Chapter two describes the problem of post-16 mathematics take-up by school leavers in England, and what the implications might be for the English economy. It then moves on to cover the current research into attitudes towards mathematics of learners in England at different key stages in their education. It then explores factors that impact upon learners' attitudes, covering the perceived difficulty of mathematics, gender, and maths anxiety.

Chapter three outlines the difficulties that were overcome when attempting to find a uniform definition of attitude, and draws comparisons between definitions used in the respective fields of psychology and mathematics education. The factors which might impact upon attitude are explored, including self-identity and group identity. It then moves onto exploring how these attitudinal factors impact upon the intention to pursue a particular course of action (for example the intention to study mathematics in post-16 education), and whether the intention to pursue a course of action will ultimately lead to its execution by a participant. Because one of the research aims of this study is to explore whether the attitudes of participants are different at different ages, the changing nature of attitudes over time is also explored. The chapter concludes with how these theories can be combined into one over-arching theoretical frame which informs the research design which has been developed to meet the research aims of the thesis.

Chapter four provides a methodological outline of how the research will be approached. The philosophical underpinnings are addressed first, followed by a description of the research design for this study, and how Likert-style questionnaires will be used alongside interviews in a mixed methods approach. The approach adopted for sampling and selection of participants is discussed, and followed by the chronology of data collection and the procedure for data analysis. Finally, ethical considerations are also discussed.

Chapters six and seven are focused on a detailed presentation of the findings of the thesis. The first section explains how the sample was chosen, followed by the practical application of the methods for key stage three/key stage four data collection outlined in the methodology chapter to the collection of data from participants in years seven, eight and nine. The data from online questionnaires and face-to-face interviews are then analysed, and the implications of the results are explored. Finally, the efficacy of the data collection instruments, and analysis of results in answering the research questions is evaluated.

Whilst this chapter has explored the relevant theoretical frames and positioned the research questions in relation to the already existing literature, the following chapters review the relevant literature and theory in depth.

Chapter Two - Literature Review

2.1 Overview

In this literature review the current of knowledge of student participation in post-16 mathematics in England is examined, as well as attitudes and values of learners which might influence their decisions to continue their post-compulsory mathematical studies. In order to place England in the global context of education, and in particular mathematics education, some of the values and attitudes towards mathematics and education from studies conducted outside England are explored. A breadth of both government policy and academic research literature will be discussed. The chapter begins with a statement of the problem, the uptake of post-compulsory mathematics education as it is currently perceived, as well as the role that it has played historically in 16-18 education in England. The English education system and its Key Stages are discussed, as well as the progress of students through these, and the curriculum requirements at each stage. The definitions of attitudes used in this thesis are clarified, and how the components of attitude towards mathematics are exhibited by learners in each of the stages of education is examined. The current knowledge of the perceived exchange value of mathematics of learners in different age groups is also examined, as well as the impact of outside influences (such as those of parents, teachers and friends), the perceptions of difficulty of mathematics of learners, the mathematical self-concepts of learners and the affective dimensions of learners towards their mathematics educations. Then mathematics anxiety is explored, as well as its relationship with the components of attitude, and the impact that these might have on the decisions of learners to study advanced mathematics. I finish my review of the current knowledge of the factors which might influence students' decisions to study mathematics post-16 with the impact of gender on students' perceptions of mathematics and their own mathematical self-concepts. The literature review concludes with thoughts on the strengths and limitations of the current knowledge of the field of study, and the research questions to address the current needs of the field.

2.2 Current numbers of students opting for post-compulsory mathematics, and why this needs to change

In recent years, policy regarding participation in post-16 education in England has evolved. Prior to 2013, there was no statutory requirement for students to participate in post-16 education. Students who left school in 2013 were all required to participate in at least a year of post-16 education, and following the summer of 2014 all students are now required to participate in some form of education until their 18th birthday. This does not necessarily mean that students must participate in the formal AS and A-Level courses discussed in the introduction chapter of this thesis. Options available to students include: full-time study in a school or sixth form college, full-time work with time for training, or an accredited apprenticeship or trainee ship (DfE, 2014).

Mathematics was one of the fastest growing subjects in 2010 choices for students opting for AS-levels, with around 70, 000 per year choosing it for post-compulsory study, and the DfE (Department for Education) claimed that this statistic was indicative of a recovery since numbers fell sharply in 2002 by 18% following curriculum changes (DfE, 2010). Whilst this statistic is perhaps encouraging in isolation, the growth in participation needs to be considered in the context of growth of all A-level entries. The increased growth in post-compulsory education mathematics participation has been less than that of the overall growth of A-Level subjects. The fastest growing subjects in the same year according to the DfE (2010) are religious studies, media and physical education. Participation in these subjects has grown at twice the rate or more than that of mathematics A-Level since 1996.

At the time when most of the literature presented here was written, not all students who participated in post-compulsory mathematics education continued to do so until the age of 18. Following their first year of post-compulsory study, pupils could opt to complete their studies after one year, attaining an AS-Level (Advanced Subsidiary Level). An AS Level was the first half of an A-Level (Advanced Level) course, and its completion is necessary for progression to the second half, known as ‘A2’. The picture was complicated by the possibility for students to elect not to study mathematics at A2 level following the completion of their AS-Level mathematics. This new possibility for attrition came with the introduction of Curriculum 2000, when the post-16 curriculum was split into modules which could be taken at the end of the first year of post-16 study, after which some students chose to study mathematics no further (Brown et al, 2007). Since then the curriculum has changed. AS levels exist as a standalone qualification, whilst to complete an A-Level students must study for two years and complete a terminal examination.

In 1976, of 14 6593 second year A-Level students, 40,441(30.8%) were studying mathematics (Cockcroft, 1982). Following the introduction of Curriculum 2000, there was a sharp drop in participation (Advisory Committee on Mathematics Education, 2012), with 68,502 UK students studying mathematics in 1999, compared with 55917 A-level mathematics students in 2003 (Smith, 2004). However, it would appear that these numbers are beginning to improve in England. In 2008, 7.5% (60,093) of A-Level students sat a mathematics exam, with a further 0.9 % (7,270) taking further mathematics. 10% (78,951) of the 2012 A-level cohort sat A-Level mathematics, with a further 1.6% (12,688) opting for further mathematics (Joint Council for Qualifications, 2012). In response to these statistics, in 2011 the secretary of state for education announced a new goal for mathematics education, that within the next ten years the vast majority of students should be studying mathematics right through to the age of 18 (Hodgen et al, 2013). Equally, it is a key goal in the research aims of the Department for Education to increase the uptake of mathematics in post-16 education, particularly amongst girls (DfE, 2014).

In order to address the perceived issue of poor uptake of post-compulsory mathematics and in response to concerns from universities and employers that school leavers do not have the mathematical knowledge required to be successful, the DfE have introduced new core mathematics courses. The new core mathematics qualification is to be offered to those students with a C or above (those who attained a C or below in GCSE mathematics are to be expected to re-sit the qualification as part of their sixth form education) who are not participating in A-Level mathematics or other post-compulsory mathematics qualification. The numbers of students taking either traditional post-compulsory courses or the new core mathematics qualification is then to be used as a national performance indicator for sixth-form education providers. Rather than the advanced theoretical knowledge gained by students on an A-level course, the core mathematics qualification aims to offer students the chance to apply the skills that they gained at GCSE to practical problems including financial scenarios and statistical modeling (DfE, 2015). Whilst this course certainly would appear to offer a solution for those students who believe themselves to be ‘not quite good enough’ to study A-Level mathematics, and whilst the addition of participation of students in post-compulsory mathematics courses to performance tables could lead to the more aggressive marketing of mathematics courses by sixth form providers, participation in the new core mathematics courses remains non-compulsory. It is unclear from the literature whether these two new measures in isolation might increase participation. It remains important then, to understand the factors which influence the decisions of learners to continue to study mathematics in post-16 education.

In addition to the perceived necessity of mathematics to the economic future of England, there is some agreement amongst researchers with regards to the importance of mathematics to social justice. Mathematics is key to working successfully in a number of fields, from practical applications including engineering, construction and carpentry to theoretical applications of number in Physics. If a student does not gain sufficient knowledge of mathematics to participate in these fields, then they are essentially excluded (Epstein et al, 2010). If this goal of increasing participation is to become a reality, it is important to look carefully at what motivates English students who are choosing A-Level options, and understand what drives them to participate, or not, in mathematics after the age of 16.

2.3 The current knowledge of students' attitudes towards mathematics

2.3.1 Primary School (Key stages 1 and 2)

When researching the attitudes of older learners towards their mathematics education, for example those in secondary school (Hodgen et al, 2009), or those in sixth form colleges (Brown et al, 2007, Murray 2011), a relatively broad literature base exists. Studies into the attitudes of younger learners (for example those in infants or junior school) are more difficult to find, particularly those which gather the opinions and feelings of learners in England. It is possible that the number of studies on the opinions of younger students remains so few because of difficulties in consulting them (Borthwick, 2011). In this section of the literature review, I examine the findings of some such studies, and some of the methodologies behind them, and consider the impact that these might have upon my study. I also discuss what gaps are left in the knowledge of the field by the existing literature, and how perhaps my study could address these.

In her 2011 paper "Children's perceptions of, and attitudes towards, their mathematics lessons" Borthwick attempts to examine some of the perspectives of English children at Key Stages One and Two of their mathematics lessons. Borthwick extrapolates students' attitudes from their drawings of their mathematics lessons using a cross-sectional sample of Key Stage One and Two students, from 4 different English primary schools. Borthwick then goes on to interview a sample of the students to gain further insights. She considered four themes in her final analysis; 'Evidence of emotions and attitudes', 'Perceptions of peers', 'Perceptions of teachers' and 'Evidence of mathematics in the drawings' in particular she notes that a range of emotions are exhibited by her participants towards mathematics, particularly that there are already elements of disaffection displayed by younger boys. Similarly, West et al (1997) examined the feelings of younger learners in Key Stage Two towards mathematics using a mixed methods approach. The analysis of their data collection provides some insight as to the children's attitudes towards mathematics at this very young age; 64% of the children surveyed were very happy with mathematics and number work, whereas 28% considered themselves to be very unhappy. From the interviews, it is possible to see some generalised views of why participants liked or disliked activities. For example common reasons given for not liking classroom activities were a dislike for sitting, listening, boredom, difficulty and not wanting to listen, although this says nothing of any reasons why the student might have liked or disliked mathematics in particular. Whilst insights into the attitudes of these learners towards mathematics remain limited, perhaps what is most pertinent to my study from this paper were the experiences the researchers had of collecting data from younger children. In agreement with Borthwick (2011), West et al (1997) concluded that collecting data from young children was not without difficulty. In particular, collecting data from the children at the interview stage was challenging. West et al (1997) noted that as the students were so young, they would often give answers unrelated to the question, preferring instead to discuss whatever they wished to. They sometimes struggled to articulate why they liked or disliked things, and on occasion did not respond to questioning at all.

Whilst West et al (1997) collected data on the attitudes of younger children as a small part of a wider study of attitudes to school, Ruffell et al (1998) gathered data on the attitudes of younger participants as a small part of a larger study into attitudes towards mathematics across different phases of education. Ruffell et al (1998) collected the views of 31 Year 6 (aged 10-11) students through group interviews, and those of a smaller sample of Year 6 children through structured individual interviews. They collected attitude data across a further four cross-sections; undergraduates, undergraduate trainee teachers, graduate trainee teachers, and experienced teachers. The premise of this research was that teachers' attitudes towards mathematics was increasingly put forward as a dominant factor in influencing those of students (Rufell et al, 1998). Like Borthwick (2011), they were not necessarily trying to gather quantitative or qualitative data on the attitudes as such, but more trying to assemble some methodologies by which data could be collected by researchers, or teachers in the future. As such, the results of the data collections are somewhat limited in terms of their analysis, and contribution towards the knowledge of the attitudes towards learning mathematics held by students of primary school age. The first set of group interviews began with the participants looking at a paper cylinder and discussing how they thought that it might have been made, without touching it. This led into a discussion where participants were asked to list what they thought mathematics was about. They then completed the sentences "I like learning maths when" and "I dislike learning maths when". The researchers recorded fewer negative statements than positive, with most of the negative statements being more related to the self than actual mathematical content. For example one participant responded with "I dislike learning mathematics when I'm tired and hot" (Rufell et al,1998:p.11), whilst another responded with "I dislike learning mathematics when I would rather be doing something else, like art" (Rufell et al, p.11:1998),. The participants in these group interviews also completed a survey in the presence of the researcher, rating different topic areas of mathematics with a cross for dislike, a plus for like, and a dash for a neutral disposition. In this part of the interview, most participants disliked decimals, citing reasons such as "I dislike decimals because there are lots of pages to do" (Rufell et al, p.4:1998), The negative comments in this part of the interview seemed to balance the positive, because whilst students reported to the researcher that "I like mathematics when it is new to me"

(Rufell et al, 1998: p.5),., another responded with “It is sometimes hard, and sometimes boring” (Rufell et al, p.11:1998),. This study, similarly to that of Dowker et al (2012) compared cross sections of children in different year groups. Both studies examine the dispositions towards learning mathematics of children in Year 5, but whilst Dowker et al (2012) opted to collect data from younger children in Year 3, Year 5 children are the youngest in the Ruffell et al (1998) study.

In a cross section chosen by Ruffell et al (2012), 14 children in a middle school, from Years 5 to 8 (ages 9 to 13) were chosen. In this research, the students surveyed were from across Key Stages, and their responses have not been broken down by year group, whereas in Dowker et al’s (2012) study, responses from Year 3 and Year 5 students are analysed separately giving some idea of how student’s attitude develop over time. Ruffell et al (1998) collected their data from their middle school participants in the form of semi-structured interviews, although on this occasion the data was gathered initially through individual interviews, then again a week later through semi-structured group interviews. Around 50% of students in the initial individual interview stage claimed to enjoy mathematics (although this is not broken down by year group), and the researchers note that the responses recorded from some students are muddled, with one boy claiming to enjoy mathematics, but also responding that he just sits and waits for the lessons to be over. There is some indication in this section though as to how responses were coded for analysis, with the most used words by the participants for describing bad experiences learning mathematics being ‘boring’ and ‘nervous’. However, this study does have an interesting dimension not explicitly examined in any of the others. Following these initial interviews, researchers returned to the school a week later to gather further data, and noted changes in how the students’ attitudes had changed in the intervening time. This is arguably useful to my research question of ‘How do students attitudes develop over time’, because although the intervening period is only a week here, Ruffell et al (1998) note some significant changes in the attitudes of the students surveyed. The same students from the initial stage were interviewed with a group of their peers. The researchers noted the advantage that conversations took place much more organically, with less prompting from the interviewer, and more responses ‘sparked’ by the other students. The researchers describe the “general flavour from the children in these interviews as bored with mathematics” (Rufell et al, p.6:1998), The participant this time described mathematics as being number-work based with lots of repetition, lack of challenge, lack of novelty and lots of routine and sitting at desks. Ruffell et al (1998) propose that this is because the children were expressing current feelings towards mathematics at the time, influenced by their experiences of the last week. They describe the feelings of children as being “highly mercurial” (Rufell et al, p.11:1998), and that perhaps the students are ‘encultured’ to describe feelings of alertness and arousal in the terms that they have come to associate with maths culturally, which in this instance the researchers claim could be ‘panic’ and ‘anxiety’.

Whilst these studies provide an insight into the affective dimension of mathematics for infant and primary school children, it is difficult to ascertain the exchange or use values (i.e. how useful learners perceive mathematics to be, either as a tool for every day usage, or as a subject which might be important for fulfilling their future aspirations) as perceived by younger students. Ashby (2009) goes some way towards addressing this issue. High attaining Year 3 students when questioned in semi-structured group interviews were able to describe in vague terms their perceived usefulness of mathematics in everyday situations, identifying for example that “numeracy is useful when you are shopping” and “maths is useful for when you are counting out money” (Ashby, p.8:2009) . Middle and low attaining students also made similar connections between mathematics and counting money. Outside of these associations though, the children did not say that they could see mathematics being useful either as a subject with exchange value, or use value for their future lives. This is perhaps due in part to the nature of the questioning used during interview. It would perhaps provide some useful insights to include questioning on the future aspirations of younger students, and if they do have ideas about their careers, whether they think that they might use mathematics instrumentally in that career, or if they think they might need some mathematics qualifications in order to access career paths that they might be in the very early stages of considering.

Not all of the studies of earlier childhood discussed here seek to identify whether young children are able to make the distinction as to whether mathematics is sometimes difficult and therefore a challenge to be enjoyed, or whether they believe that mathematics is something they need for their lives after school. It is also possible that the children simply view mathematics as something that needs to be done. This is perhaps a direction that is worthy of further investigation

2.3.2 Secondary School (Key Stages 3 and 4)

2.3.2.1The affective dimension in secondary school students

When compared with those studies examining the attitudes of younger students towards mathematics (Borthwick, 2011, Dowker, 2012, Ruffell et al, 1998) a fairly strong body of evidence exists as to the affective perceptions of mathematics of secondary school learners. The Royal Society argue that in the literature that they reviewed, students surveyed viewed mathematics as “isolating, over-individualized, involving a high reliance on dull repetition and rote learning” (Royal Society, p176:2008), a position mirrored by Brown et al (2007). who also identified that a significant number of students who had chosen not to progress to A-level cited that they made this choice because they perceived that mathematics was dull and required rote-learning. There is a strong correlation between how much students like and enjoy mathematics and their participation in advanced mathematics (Brown et al, 2007). This position is corroborated by Epstein et al (2010); who conducted a study carried out in three phases, including questionnaires to Year 10 students and second year undergraduate students, focus group discussions and then finally individual interviews. They also noted that there is a strong correlation between enjoyment of mathematics and its continued study in post-compulsory education. It is important to consider that perhaps factors affecting the choices made by students cannot be isolated, and some are dependent on others. Particularly noticeable in Epstein et al’s (2010) work was that the affective dimension when deciding not to continue with mathematics in post-compulsory education was particularly apparent in students who found the subject difficult. Often, this was associated with not being able to understand it. One student described how she “….hated it. Straight up hated it” (Epstein et al, p.55:2010),.Another undergraduate student who had gone on to study English talked of how he passed, but that he burnt his mathematics book on the day that he got his GCSE results.

There is some significant variance in how much students across the globe enjoy mathematics. According to the 2012 PISA survey (OECD, 2013) most participants reported that they did not enjoy mathematics. Whilst 70% of students in Indonesia, Malaysia, Kazakhstan, Thailand and Albania reported enjoying mathematics, only 30% in Croatia, Austria, Serbia, Slovenia, Hungary, the Slovak Republic, Finland and Belgium reported enjoying mathematics. Unfortunately from the data provided it is not possible to know why students in these countries do not enjoy mathematics, or whether these negative feelings would prevent them from taking more advanced mathematics courses, or whether there are other attitudinal factors which are more important to them when they consider their mathematics educations. What the PISA analysis does make clear is that levels of enjoyment are key to mathematical performance, with students who self-reported that they did not enjoy mathematics and were not interested in mathematics lessons more likely to perform less well on the associated skills tests that those who reported high levels of enjoyment and interest.

Van der Beek et al (2017) provided questionnaires to 1014 9^{th} grade (aged around 15 years and one month) in eight secondary schools in the Netherlands. This particular research did not seek to explore how the attitudes of the students towards mathematics changed over time, but to understand the relationship between mathematical self-concept, mathematical achievement and emotions. The study did not attempt to explore the impact of these on future decision making, but to understand the relationship between these constructs at the time that the questionnaires were completed. Whilst the study is limited to the age group surveyed, some insights useful to the research presented in this study emerged. The researchers found indirect effects of attainment on self-concept, which in turn impacted upon enjoyment and mathematics anxiety. They found that the participants did not rely on their immediate performance to inform their self-concept, but on their performance over time. They also found that the relationship between emotions and self-concept was stronger than that of self-concept and actual achievement. This could mean that students won't necessarily base their self-concept on their assessed attainment, but rather how they feel about their own ability. This would appear to share a relationship with students' motivation, and their intention to study mathematics later in their educations (Preiss-Goben and Hyde, 2016). Preiss-Goben and Hyde (2016) conducted a longitudinal study which gathered insights into participants' perceived self-concept and their motivations to study mathematics over time. They used implicit theory (that humans have basic beliefs about their own abilities; for example whether their ability is fixed or malleable). This study (Preiss-Goben and Hyde, 2016) is particularly pertinent to the research presented in the chapters which follow, as it sought to explore motivation over time, and examined self-concept. It did not examine other factors such as perceived utility or normative influences. Data was gathered using online questionnaires in their own homes in Ninth Grade, twelfth grade and two years after high school. They found that self-concept was the most important indicator of course-taking after mathematics was no longer compulsory. Those students who believed themselves to be 'good enough' were more likely to take post-compulsory mathematics courses.

2.3.2.2 The current knowledge of students' perceived exchange value of mathematics

The usefulness of mathematics for university and careers is a key contributing factor in the decision of students to study A-Level Mathematics (Matthews and Pepper, 2007). Evidence from the Understanding Participation rates in Post-16 Mathematics and Physics project (UPMAP), which explores the factors which shape the engagement of students with mathematics Post-16 through questionnaires, lends further support to this assertion. Amongst the students surveyed, a larger number perceived a lower intrinsic (the enjoyment and study of mathematics for its own sake) than extrinsic (the value of mathematics as a ‘door opener’, either to further study or for financial gain) value in mathematics (Mujtaba et al, 2010). This would suggest that whilst students perceived an exchange value in studying mathematics, relatively fewer were enjoying it as a discipline. Not all of the evidence from the literature is in agreement with a perceived exchange value of mathematics being key to deciding to continue to study it. Brown et al (2007) identify that in spite of government rhetoric that mathematics is vital to the future economic well-being of both students and the economy at large, sixth formers believed mathematics to be less important to their career aspiration than other science subjects. One student identified that they had dropped mathematics in favour of economics; a course which they perceived had more real world value. Students of lower attainment (in this case meaning students who were predicted below an A*), were more angry at the perceived uselessness of mathematics learnt in class, with one student stating that “The amount of insignificant mathematics work that I will NEVER use is quite big” (Brown et al, 2007:p.9),.Evidence from Noyes and Sealey (2012) also appears to support that sixth formers do not always perceive an exchange value in mathematics, with only one student from the study expressing that they had chosen mathematics AS level with a specific career aspiration in mind.

Hernandez-Martinez et al (2008) selected students from five different sixth-form colleges around the UK who had chosen to study mathematics at AS level. The researchers interviewed them about their perceptions of mathematics, its usefulness to them, and the likelihood that they would engage in further post-compulsory mathematics education. Unlike Black et al (2009), and Rodd et al (2010), the students were not ‘high attaining’, having achieved GCSE C grades or below, rather than the A grades that Rodd et al’s (2010) undergraduates had previously attained. These studies are of particular interest to this literature review, since they were not representative of the general population of sixth-formers, but rather are representative of a band of students of particular interest, those who cause concern for wider participation in post-compulsory mathematics education. The researchers investigated why the students had come to sixth-form college, and why they wanted to go to university, dividing their responses into four ‘interpretive repertoire styles’ which identified their motivations for study. These were ‘becoming successful’, ‘personal satisfaction’, ‘vocational’, and ‘idealist’. For each repertoire, the researchers examined students’ aspirations, their influences upon their aspirations (discussed here in the subjective norm section), and their visions of mathematics. Views of mathematics in this study were clearly linked to students’ aspirations, unlike Brown et al (2007), and the exchange or use values perceived by the students were clearly visible. The students identified as belonging to the ‘becoming successful repertoire’ responded that university could lead to high status jobs, such as being an accountant or lawyer, and in turn might lead to prosperity. They then investigated the role that the students perceived that mathematics might play in these aspirations. Black et al, 2009 noted that the students saw mathematics as being instrumental in university entrance, a high status subject that might ‘move one along a career path’. Whilst they also responded that mathematics was ‘hard’ and ‘not relevant for everyday life’, they could see that it might be helpful in the future rather than now. Although there were some indications that these opinions had been influenced by parental hopes, it was unclear at the stage that the students had been interviewed when they had become aware of these influences, or when they had become aware that university, and by association mathematics had become important for their hopes of future success. There was a group of students within those interviewed whose career choices were not particularly ‘respectable’ (Hernandez-Martinez et al do not make explicit what ‘respectable might mean here) or dominant. Their choices remained open, and their interviews focussed upon their personal interests and what they enjoyed. Whilst the prominent subjective norm in these instances was still their parents, their parents wanted them to ‘be happy’ rather than to follow a particular career path.

It is worth considering how students perceive the views of their parents, and whether students whose parents wish them to ‘be happy’ are less focussed upon the exchange and use values of mathematics, but rather more focussed upon enjoyment. The students in this sample had chosen to study post-compulsory mathematics, and in this instance talked of enjoying maths, and having a fairly good mathematical self-concept, asserting that they understood it. They spoke of enjoying it, even if they had a rough career plan for which it was not necessary. Students who were categorised into the third repertoire had a clear vocational pathway, were overwhelmingly male, and had no consistent external influences upon their aspirations. They perceived a strong use value in mathematics, and in common with one particular case (which is discussed in further detail in the following paragraph) in Black et al’s (2009) study, mathematics was strongly aligned with their future visions of themselves as engineers. Students identified as belonging to the ‘idealist’ repertoire held aspirations of an escapist future significantly different to the reality in which they currently lived. Many of these dreams were long held, which perhaps would suggest that it is worth considering the career aspirations of younger (infant and junior school aged) children. The external influences in these instances were often TV shows and movies. They were quite often the first in their family to consider university entrance, meaning that the parental impact upon educational choices here was not as influential as perhaps it was in some of the other repertoires. Many of these students did not know in any depth how to go about achieving these dreams, and as such mathematics did not have such a central role. They stated that they chose mathematics because it seemed like a good idea at a specific point in time, for example they quite liked it at school. There is evidence to suggest that students from outside of England and the UK consider the exchange value of their educational choices, for example students in Germany as well as England reported that they chose their advanced qualifications in order to help them get a better job (Glaesser and Cooper, 2014). It is worth investigating perhaps, whether younger students of similar attainment (3/4 borderline students, with a Grade 4 being the minimum acceptable pass grade without a requirement to re-sit GCSE Mathematics during Year 12), hope to attend university, and whether they see further qualifications in mathematics as instrumental in achieving their goals, or whether like the students in the idealist repertoire they have a vague idea that it 'might be good idea' for their ideas of their futures. Since these are the students that are most unlikely to participate in post-compulsory mathematics education, this study is potentially of benefit to them.

There is a distinction between the exchange value of mathematics, and the use value of mathematics. This is illustrated by Black et al (2009). The researchers interviewed two students, Mary and Lee (ages 16-17) in post-compulsory education. As a part of the 'Keeping doors open to mathematically demanding F&HE programmes' project, which investigates students' participation in AS Level mathematics and use of mathematics, the researchers carried out interviews with 40 students. Mary and Lee were two of these students, and whilst both saw the value in studying AS Level mathematics/use of mathematics, they attributed value to it for different reasons. When interviewed, Mary discussed her future aspirations as an engineer. She described how mathematics made it possible for her to work out measurements when designing animals. She stated that she enjoyed the maths that she needed for making things. However, when interviewed a second time 9 months later, she discussed how she had felt the need to drop out of AS level statistics because she felt that she was at risk of failure. In this longitudinal (albeit over a short period) study, the researchers were able to observe changes in Mary's perceived exchange and use values of mathematics. Whilst Mary described enjoyment of the subject, and its usefulness to her and her enjoyment of engineering, its importance to university entrance so that she was able to do her Higher Education engineering course later meant that the exchange value of the subject, became more important to her than its use value. Lee stands out in contrast to Mary, in his perceptions of mathematics as a subject with an exchange value, and in his perceived usefulness of it in relation to his everyday life and his future aspirations. Like Mary, Lee participated in two interviews with the researchers 9 months apart. In his first interview, Lee had not yet fully developed his ideas of his future career. He knew that he identified himself as someone who would go to university, but had not yet decided what he might study. He described how he had needed to drop AS level mathematics, because of the risk of failure, and therefore the risk of his future university career. He has been encouraged to take ‘use of mathematics’ AS Level instead, which he felt was just as hard as AS Level maths, and largely irrelevant to his everyday life, saying in interview that he was ‘not interested in the price of coffee’. When interviewed 9 months later, Lee had decided that he would really like to study psychology at university. Whilst he still wasn’t enjoying mathematics, he had a renewed interest in his mathematical studies, because he wanted to get his AS level in mathematics in order to get into a good university. He discussed with the researchers how he wasn’t interested in pursuing mathematics for its own sake later in his education, but would participate in studying mathematics if it were a necessary part of his degree, and relevant to his chosen field. In this example, it can be seen that it is possible in the highly pressurised AS level year of post-compulsory education that potentially perceptions of the exchange and use values of mathematics to change over a short period of time, depending on the aspirations of the participants. It is possible for students at this stage in their education to have differing perceptions of the usefulness of mathematics depending on their leading identities, in this instance either as an engineer or as a generic university student. We saw in this example how a students’ ideas of his future career can crystalize over time, and that they are not fixed. It would seem here that the deciding factor was the pressure of looming university entrance, and it is of value to understand whether similar pressures lead students to make similar decisions earlier in their mathematical educations.

The evidence of the perceived exchange and use values of mathematics in Key Stage Three is a little scarcer than that of students in Key Stages four and five. Amongst those students surveyed by the National Audit Office (2008), only just over half identified that mathematics was useful outside of school. In this instance the data does not reveal in which ways the participants felt that mathematics could be of use. Whilst the participants in Epstein et al’s (2010) study were older (with participants in Year 10, and some in their second year as mathematic undergraduates), there were marked differences in attitude between those who continued to study mathematics at an advanced level and those who already identified in Year 10 that they had ‘given up’ on mathematics thought about the use of mathematics outside of lectures of lessons. Those who had not given up had ways of thinking about mathematics that permeated their whole world. They perceived use of mathematics not only as ‘mental maths’, for example using mathematics to work out change, but as a tool for more generalised problem solving. Those who had ‘given up’ identified its use as simple numeracy. It is important then to understand how useful students perceive mathematics to be and why, if we are to understand why some students may elect to give up studying mathematics when it is no longer compulsory.

A positive instrumental vision of mathematics has other important implications outside of making further and higher education choices. Students who self-report low levels of instrumental vision of mathematics generally do not perform as well as those who report that they believe that mathematics is useful for their future careers (OECD, 2013, Mendick et al 2007).

2.3.2.3 The perceived difficulty of Mathematics

A number of studies (Murray 2011, Brown et al 2007, OECD 2013) have found a wide perception amongst students of upper secondary school age (ages 14-16) that mathematics is a difficult subject. Murray (2011) interviewed 92 Australian students from two comprehensive secondary schools on their perspectives of the factors that might drive students to decline participation in Post-16 mathematics. Mathematics is not compulsory in the final two years of secondary school in Australia (Murray, 2011). In England, students finish compulsory mathematics when they take their GCSEs (Noyes and Sealey, 2012). Therefore the two countries have similar systems of opting for Post-16 course with no compulsory subjects, making them worthy of comparison. The most common reason given by students in the study for declining to participate in post-compulsory mathematics was difficulty, which was cited by 60% of the students surveyed.

Whilst it is possible that these perceptions are built from participants' own experience and prior attainment, it is also suggested that the perception of difficulty does not come from the personal experiences of the students themselves, but from outside influences, for example from the experiences of friends, family and teachers. The notion that AS Mathematics is difficult comes from older siblings who are on, or who have already completed the AS course. Brown et al (2007) suggests that students might use these perceptions with a sense of relief as a rationale for choosing not to continue with their mathematical studies. Since the perception is external, to them it is therefore perhaps acceptable. This would suggest then, that there may be some impact of external influences, or the subjective norm, upon the decisions of secondary school students to study mathematics at AS Level. It is impossible to tell from these studies at what age these students began to observe the feelings of their parents teachers, or older siblings as being an influential factor in their perceptions of mathematics, or on their decision to continue to study it in post-compulsory education. It is also impossible to tell from the studies of the attitudes of younger children (Borthwick 2011, Dowker et al, 2012, Rufell et al, 1998), whether the attitudes that they exhibit are all of their own construction, or whether they might be influenced by external thoughts and opinions. Since it is not possible to know from the current studies of the older children when they began to notice and internalise their subjective norms, or whether the younger children had any at all, at the moment we do not know at what age opinions and attitudes of parents, teachers and friends might begin to affect children's perceptions of mathematics, or whether their subjective norms change or develop during the course of their education.

The DfE (2010) argues that prior high attainment is a factor in the decision to study mathematics at AS-Level. When analysing school census survey data, it was noted that pupils who achieved above the expected level prior to Key Stage 5 in mathematics were most likely to take A-Levels in Mathematics. Pupils with high prior attainment at Key Stage 1 were nine times more likely to enter A-Level maths than those who attained at the expected level or below, and those with an A or A* were 88 times more likely than pupils without to opt for mathematics. It could be that pupils without A or A* grades felt that mathematics was simply 'too difficult' for them, perhaps as asserted to them by teachers who felt that for those with less than a B grade, mathematics was 'not worth studying' (Brown et al, 2007). It could also be perhaps that students who were not 'high attainers', experienced the opposite of those who had been attaining at above the expected level since key stage one. Perhaps the lack of desire to study A-level mathematics can be attributed to repeated instances of failure, leading students to become 'maths anxious' (Dowker, 2012). It is possible for a student after several successive failures to believe that they can never catch up, and feel 'left behind' by the system. In these instances, it is possible that students will just stop trying, since they see no point in continued effort (Walls et al, 2009). In agreement, the DfE (2010) found in their survey data that the most important factors in both mathematics and science uptake and achievement were not only enjoyment of the subject and working hard at school, but a belief in one's capacity with the subject. This would appear to be directly supported by global evidence gathered in the PISA survey (OECD, 2013). The OECD argues that this is related to the theory of self-efficacy proposed by Bandura (1997); that whilst better performance in mathematics leads to higher self-efficacy, students who have low mathematical self-efficacy are at a higher risk of under-performing in mathematics in spite of their abilities. This assertion would appear to be supported by their data. Whilst 59% of students in the survey reported that they attained good grades in mathematics, 43% of students either agreed or strongly agree that they were not good at mathematics. However, since 59% of students often worried that mathematics lessons would be too hard for them, it appears that generally the nature of the relationship between mathematical self-concept, prior attainment and the perceived difficulty of mathematics is a complex, and in need of further exploration.

It is interesting to note that it is possible for two students to perceive the difficulty of mathematics in different ways. It does not necessarily follow that perceiving mathematics as 'difficult' is a barrier to a student continuing to study it. In Epstein et al's (2010) study, nearly all the participants identified that mathematics was ‘difficult’ and required a lot of work, including those who were second year mathematics undergraduates. It is entirely possible that the same belief (in this instance the perceived difficulty of mathematics) can elicit different emotions in individuals (Di Martino and Zan, 2009). When interviewed, Mary and Lee both identified mathematics as being difficult. However, whilst Mary identified mathematics as being challenging in a way that she found to be fun, and useful to reach her ultimate goal of becoming an engineer, Lee perceived the difficulty of mathematics as something which might interfere with him reaching his goal to be a university student, and as such found the difficulty of mathematics to be a reason for abandoning his study of AS level mathematics, since it was of no particular interest to him. Mary also abandoned her AS level statistics course, but thought that it might be something to which she could perhaps return later on, once it wasn’t critical for university entrance (Black et al, 2009). This is further corroborated by Epstein et al (2010), who note that that the perception that mathematics is difficult and requires a lot of hard work was prevalent across all the students that they interviewed, both those in secondary education, and those who were mathematics undergraduates. The defining characteristic between those students who identified themselves as mathematicians and those who identified that they did was an affective response to the perceived difficulty. Research from outside England and the UK also reflects this position, Walls (2009) interviewed students from New Zealand, Australia, Sweden, England and Switzerland in a longitudinal study throughout their mathematics educations, with one final year student noting that he found figuring something difficult out rewarding, and that this was most likely to happen in mathematics rather than other subjects such as history. It is possible that students not only enjoy the feeling of persevering to solve a difficult problem, but also a perceived social cachet that comes with being a member of an elite that is good at mathematics. When interviewed one mathematics undergraduate reported that it felt good to know that he was a member of an elite, whilst another commented that part of the fun of mathematics was that ‘not everyone was into it’ (Epstein et al, 2010). This is further supported by research presented by Martinez-Sierra and Garcia Gonzalez (2017). In this research focus groups were used to gather the opinions and attitudes towards mathematics learning of 53 students between the ages of 16 and 18 in Mexico. Whilst a limitation of this study is that only one age group is sampled, some salient points were raised which are relevant to the research presented in this study. Researchers found that participants felt proud when they completed a mathematics problem if they viewed it as a target to be met.

Research has also investigated the participation in A2 mathematics of students who have completed AS-Level. Noyes and Sealey (2012), note that there is the possibility for attrition from post-compulsory mathematics study once the AS level year is complete. Rodd et al (2010), as part of strand 3 of the much larger UPMAP project, interviewed first year undergraduates about their mathematics education, and their choices to study STEM subjects, or not, in higher education. Whilst the interviews focussed primarily on the students' choices regarding their university degrees, some useful insights can be found as the students were encouraged to begin the discussion starting with any point in their mathematics education they chose. The researchers interviewed them, then analysed the transcribed text. Thirteen of the interviewees were studying STEM subjects at undergraduate level, and like Mary, those in engineering or physics disciplines considered mathematics as a tool for reaching other goals (Black et al, 2009). Those studying pure mathematics did not cite its usefulness as a reason for their choices. Of the nine students not studying STEM subjects, eight had an A grade at mathematics A-Level. They all explained that they felt were 'good' at mathematics, which was why they had chosen it at A-level. In spite of their high mathematical self-concept, they cited a lack of relevance and difficulty as reasons for not continuing to study it at university. When explaining why he chose not to study A2 further mathematics, one student explained that as the concepts became more complex, he could no longer see any use of them in his day-to-day life. For this student, Peter, a point came at which the difficulty of the subject outweighed its use value. Although for him the tipping point came between the conceptually high-level AS and A2 mathematics, this is unlikely to be the same for all students. Lee found a new turning point once he had decided on his future career path (Black et al, 2009). It is possible that other students may reach their tipping points earlier on in their careers, and it is therefore worthy of study to find what the significant events may be that might influence a student's choice to study mathematics when it is no longer compulsory, in particular during the earlier years of education, since this has not been so well evidenced by large scale studies such as UPMAP.

2.3.2.4 Mathematics and the sense of self, and how this might be affected by external influences

A sense of oneself as a mathematical subject refers to how a student perceives themselves as a mathematician (Walls, 2009) and differs from mathematical self-concept which refers to how good or bad at mathematics a student perceives themselves to be (OECD 2013, Di Martino and Zan 2009). A leading identity is a reflexive understanding of one's self (Black et al, 2010) i.e. how a student perceives themselves. A student could position themselves as being someone who is more creative than mathematical, for example. A student's decision making is heavily connected to their understanding of themselves (Black et al, 2009).

Therefore the sense of self is key to understanding why a student may opt, or not to study mathematics as part of their post-16 choices.

The concept of oneself as a mathematical subject can be affected by a number of factors. Mendick et al (2007) interviewed 26 school students and 23 university students in order to ascertain how they perceived themselves, and how this impacted upon their continued study of advanced mathematics. They found a strong opposition between the desire to study mathematics, and the perception of oneself as ‘creative’, with one student explaining that they did photography because they are a ‘creative person’. Mendick et al argue that other factors such as enjoyment, previous attainment, and the future happiness and success of students (all of which have been discussed in this literature review) are held together by a sense of identity, and that the themes that arose the most as being factors in continuing to study mathematics were not only ability and enjoyment, but a perception of oneself. Those students who did not wish to pursue advanced mathematics perceived it to be rigid with clear answers, and little room for self. Both those inside and outside of advanced mathematics courses maintained that there were boundaries between those who were ‘mathematical’, and those who were not, and the perception of those who were mathematical as being geeks and therefore socially awkward was a common theme in the interview data. The understanding that mathematics is not a ‘creative’ pursuit is not unique to Mendick et al’s (2007) participants, and is not unique to England and the UK. Boaler and Greeno (2000) interviewed students from four American high schools who were in advanced calculus classes. The students were expected to complete tasks by using methods prescribed by their teachers. The students surveyed who did not wish to pursue the study of mathematics further identified that because they needed to use the prescribed methods, there was no room for creativity. They perceived that because of this they needed to give up their creativity if they were to become ‘mathematical’ people. The differences between how they perceived themselves to be (creative), and the identity that they needed to assume in their mathematics classrooms (by following instructions with no room for their own perceived creativity) were irreconcilable. Boaler and Greeno identify this as the source of students’ alienation from mathematics. Walls (2009) suggests that eventually, students will tie their own ultimate success or failure to whether or not they are a ‘mathematical person’, meaning that they felt that some people were just more mathematically able than others.

Mendick et al’s (2007) participants downplayed the role of their parents in making decisions about their future courses of study, citing that whilst their parents supported their choices, the choices that they made were their own independent acts. The impact of parental influence extends beyond students in England, and beyond the decision to study mathematics. In Germany, where a system of attending different secondary schools based upon previous attainment exists, students were more likely to wish to attend a Gymnasium (school for higher attaining students), or university if their parents wanted them to, regardless of their attainment. The same was true in the opposite direction; students whose parents did not want them to (the study explores social reasons why this might be the case) go onto study at the Gymnasium said that they would continue to study at the Realschule, with one student stating that his mother ‘does not like the Gymnasium’ (Glaesser and Cooper, 2014). Evidence from PISA (OECD, 2013) suggests that parents might exert influences on students of which they might not even be aware. Whilst Glaesser and Cooper’s student was able to make a direct correlation between his mother not liking the Gymnasium and his decision to not attend, the students who took part in the PISA study were more likely to have more perseverance, and a greater intrinsic motivation to study mathematics if their parents had high expectations of them i.e. if their parents had general high aspirations for their children, such as attending university or holding a managerial position one day. Equally students whose parents held such high aspirations for them were more likely to engage with school and have a high mathematical self-concept. These factors appeared to have a greater influence on students than simply believing that their parents thought that mathematics would be important for their future careers (with around 80% of participants believing this to be the case). This position would appear to be supported by Epstein et al (2010), who found that the better a student perceived that they were at mathematics, the more encouragement they felt that they had previously had from their parents and teachers.

Perhaps also of importance is a student’s perception of what a mathematician is. When Epstein et al (2010) interviewed both secondary school and second year mathematics undergraduates, most described a mathematician as someone who was old, white and male. Interestingly, this was also the perception of a number of female mathematics undergraduates. Since there was no direct one-to-one correlation between a vision of what a mathematician looked like, and the desire to go on to study mathematics (although some of the mathematics undergraduates identified with the image of a ‘cool’ mathematician), this is probably not a direction worthy of further study. This appears to be supported further by findings from Mendick et al (2007), who found that images of mathematicians in popular culture did not have an impact on the decision of students to study advanced mathematics, with one student citing that if you were strong at mathematics then you would probably continue with it, whereas if you were weaker then you would stop, regardless of what popular culture encouraged.

2.3.2.5 The impact of gender upon the decision to study Mathematics post-16

The volume of literature examining the correlation between gender and its impact upon the study of mathematics, and related subjects such as physics and chemistry is not inconsiderable. It is examined in both large scale projects (Royal Society, 2008) in research with smaller samples of participants (Mujtaba et al, 2010, Jones, 2008, Brown et al, 2008, Dowker et al, 2012), and in government publications (DfE, 2010).

In 2008, The Royal Society 'state of the nation' report on pupils' attainment in mathematics and science presented the findings of a large scale comparison of all GCSE and A-Level entries and results with PLASC (Pupils Annual School Census) data on gender. This enabled them to make comparisons between the relative choices and attainment of male and female students. There appear to be some gender differences in progression to A-level mathematics. Data for girls progressing to A-level mathematics show lower post-16 participation than for boys (Royal Society, 2008). The work of Mujtaba et al (2010) supports these findings, echoing that gender is a significant predictor of intention to study mathematics, with more boys opting for further study than girls. These findings are supported by Brown et al (2008), who note a persistent gender gap over time, with males making up 62% of the 2006 A-level Mathematics entry. It should be noted that this Royal Society report is now relatively historic, and it is worthy of further reading into how progression to A-level mathematics has changed over the intervening years.

Jones (2008) used closed questions to survey 375 Welsh Year 12 students on their attitudes towards mathematics, and examined how these might influence their decision to participate in its post-16 study. The girls surveyed appeared to enjoy mathematics less (56.8 % of girls claimed that it was not enjoyable), than the boys surveyed (46% said that it was not enjoyable). Girls also appeared to be significantly less confident with only 19.3% of girls predicting an A grade for themselves, compared with 36.4% of boys. She also noted that 55% of the girls surveyed said that they felt anxious when studying mathematics compared to 26% of the boys. The survey provides some insights into relative enjoyment and self-concept of boys and girls, but the questions used did not allow the participants any way of expressing why they held these opinions. Data from the Department for Education (2010) supports these findings. Girls are more likely to achieve higher (A and B grades) in A-Level Biology than boys, but are less likely to achieve similar passes in Mathematics simply because the number of entries of girls into Mathematics, Physics and Chemistry are lower than entries of boys into these subjects. One explanation for the disparity in numbers of boys and girls entering post-compulsory mathematics education is perhaps the context in which mathematics sits. Whilst the performance of girls at the age of 16 is not worse than that of boys, it is worse in comparison with the performance of girls in other subjects. So whilst perhaps girls are not ‘underperforming’ when compared with boys at the age of 16, it is possible that they might be opting for subjects in which their performance is ‘better’ compared with their performance in mathematics (Noyes, 2009). This appears to be true for both students in and outside of England, with girls in the PISA questionnaire being more likely disagree that they are someone who can handle a lot of information well and are quick to understand things. Equally, girls were more likely than boys to agree that they felt responsible for poor performance in mathematical tests, and in several countries on several indicators said that they felt in control of their mathematical performance (PISA, 2013).

There seems to be little doubt that there is a correlation between being female, and confidence in one’s mathematical capability, or that girls are less likely to ultimately choose to study mathematics, or a related subject in their post-compulsory education. What is a little more unclear, is at what age girls develop these perceptions of their abilities. With the exception of Dowker et al (2012), who found a clear correlation between gender and self-rating, with girls more likely to have a lower self-rating than their male counterparts, it is difficult to tell from the studies of younger children whether gender impacts the mathematical self-perception of younger children (those aged 5-7 for example). It is also hard to tell from any of the studies discussed here what might make boys more confident to study mathematics than girls, so although there a general agreement that girls might be less confident, there is no further examination as to which factors might influence these self-perceptions, such as do parents or teachers encourage boys to believe more in their own abilities, or are there any significant events that girls might be able to identify that could explain their self-perceptions?

Holm et al (2017) suggest that males and females have different perceptions of their perceived ‘failure’ in mathematics. They conducted a study with 1358 eighth grade participants in Finland across 27 different schools. Participants completed a mathematics test, and a questionnaire related to emotions. This study again used a different definition of attitude and its components to others, and did not provide any insight into how the attitudes reported by participants might have developed over time. This was an analysis of performance and self-reported feelings towards mathematics at a specific point in time. The researchers found that low-attaining male participants were less likely to report that they did not enjoy mathematics and experienced negative emotions than female participants who also attained lower scores in mathematics assessment.

It is also possible that girls are simply more likely to desire careers that are not ‘mathematical’ by nature. As seen in the ‘Current knowledge of the perceived exchange value of mathematics' section of this literature review, students in general attach an importance to mathematics in terms of an instrumental value for their chosen careers (Black et al 2009, Hernandez-Martinez et al 2008), but according to the OECD (2013), girls were less likely to report that mathematics would be useful for their chosen career. 78% of boys, compared with 72% of girls could see the value of mathematics in the labour market, and only 61% of girls compared with 71% of boys agreed that mathematics would be useful in their chosen future courses of study.

2.3.2.6 Mathematics Anxiety and the decision to study mathematics post-16

Mathematics anxiety is a negative emotional reaction to situations which involve mathematical problem solving (Young et al, 2012). It is possible that a negative attitude, such as that exhibited by those who are mathematics anxious, affects a person’s willingness to persevere, which in turn hinders mathematical development (Ashby, 2009). OECD (2013) noted a 34 point difference in attainment on mathematics PISA tests between those students who identified that mathematics made them anxious, and those who did not. This 34 point difference equated to a year of school, meaning that those students who self-identified as having mathematics anxiety attained at the level of a student a year younger. If mathematics anxiety hinders a person’s willingness to persevere, then this eventually might be a deciding factor in whether or not a student continues in their mathematical studies after the point at which it ceases to be compulsory. Research by Ashcraft and Krause (2007) suggests that in turn, this tendency for people who are highly mathematics anxious to avoid mathematics means that they avoid elective courses in mathematics, both at secondary school age and in further education courses. They may also later avoid career paths that have a mathematical component, making the issue of mathematics anxiety a factor which needs investigation in the context of how students’ attitudes change over time, and how these might one day affect their decisions to study mathematics as AS or as a complete A-Level.

Whilst researchers disagree as to what the causes of mathematics anxiety might be, how it could be treated and the effect of it on the mathematical performance of participants, there seems to be a wide agreement that mathematics anxiety has a significant impact on a student’s decision to study mathematics. It is arguable that early mathematics anxieties may “snow-ball” and eventually lead students, even those with high mathematical potential, to avoid mathematics courses and careers (Ramirez et al, 2012).

Some studies suggest that attitudes towards mathematics deteriorate with age, especially during secondary school. In particular, Dowker et al (2012) note that mathematics anxiety is likely to increase during the later primary school years (it is worth noting that the same study also observes an increased liking for mathematics, which is somewhat ambiguous!) (Dowker et al, 2012). It is possible that early mathematics anxiety snowballs as students progress through their mathematical educations. This exerts an ever-increasing cost on achievement as it changes students' attitudes and motivations, and begins to interfere with cognitive processing. Ramirez et al (2012) note that this becomes increasingly prevalent in later schooling, particularly when students are given autonomy to choose their courses. It is also suggested that mathematics anxiety is associated with students choosing not to follow mathematics intensive courses at university, and is particularly problematic as mathematics anxiety has been observed in those training to become elementary school teachers, who risk passing on their anxieties to their future students. Dowker et al note that whilst there is not necessarily a relationship between mathematics anxiety and performance, there was a significant relationship in the results of their study between anxiety and liking mathematics. They observed that there was, unsurprisingly, a strong association between a freedom from anxiety and a liking for mathematics. This was in surprising contrast to liking mathematics, and actual mathematical performance, between which in the children surveyed there did not appear to be a correlation (Dowker et al, 2012).

The suggested causes of mathematics anxiety vary widely across the literature. Research by Dowker and colleagues suggests that the cause and effect nature of mathematics anxiety and poor mathematics performance might be a vicious circle. One possible cause of reduced performance related to mathematics anxiety might be that individuals who are highly mathematics anxious might seek to avoid activities and situations that involve mathematics, and therefore have less practice. They also suggest that poor mathematical attainment could lead to mathematics anxiety, as a result of repeated experiences of failure (Dowker et al, 2012). Devine et al (2012) describe this as the deficit theory, which is to say that mathematics anxiety arises as a result of awareness of past poor performance in mathematics, they contrast it with the Cognitive Interference theory, which asserts that mathematics anxiety arises as a result of anxiety interfering with recall of past knowledge. Maloney and Beilock (2012) suggest that the causes of mathematics anxiety could be social. They suggest that individuals who are exposed to teachers who are mathematics anxious were at risk of developing similar anxieties themselves. They suggest that it is possible that some individuals who have pre-existing difficulties with processing numbers are more likely to be negatively influenced by these kinds of external social factors (Maloney and Beilock, 2012).

2.4 Changes in attitude to mathematics over time

According to the literature surveyed, it would appear that moving from primary to secondary school has a noticeable impact upon the attitudes of students both towards mathematics and towards school in general. McLeod (1994) notes that students' attitudes towards mathematics become more negative as they move from primary to secondary school. This position is further supported by the National Audit Office (2008) who surveyed 350 Year 7 and Year 8 students in secondary and middle schools in England and Wales. Whilst students were generally very positive about mathematics (e.g. reporting that they liked it, and that they could see its utility outside of school), 74% of the students surveyed reported that they found mathematics harder at secondary school than at primary school, with a greater proportion of students in Year 8 reporting that this was the case. The students in Year 8 were more likely than those in Year 7 to agree that they did not like mathematics, with only 40% agreeing that they liked it, compared with 43% of the Year 7 students. Boaler (1997) also observed a student in Year 11 noting that she enjoyed mathematics more in primary school because of the varied nature of instruction. This is further corroborated by Walls (2009), who engaged in a longitudinal study of Australian school children between the ages of 7 and 18. By the end of the study, the attitudes of students towards mathematics, and confidence in their own abilities had deteriorated radically, with most reporting that they did not feel as confident as they did when they were younger, and that most now believed that they did not have an inbuilt aptitude for mathematics.

Whilst researchers appear to agree that the attitudes of students deteriorate over time (Dowker 2012, McLeod 1994, OECD 2013), finding an explanation for this deterioration is a little harder. Hannula (2002) worked with a student named Rita from the time that she entered secondary school in Finland until the time that she left, both as a researcher, and for part of the time as her maths teacher. Rita described mathematics in elementary school as being much nicer than mathematics in high school. When she was in Year 7, Rita claimed not to like mathematics as she found it dull, and could not see the utility in what she was learning. When observed, the reasons at least in part for Rita's dislike of mathematics appeared to be social. When observing Rita participating in a group task, Hannula noted that she was excluded from discussion with the two other girls with whom she was working. It was following this incident that Rita declared that the work she did in mathematics was pointless and not needed. In this instance, the task-related emotions experienced by Rita were intertwined with feeling rejected by her peers. Interestingly, Rita's attitude improved over time following this early incident in secondary school. She eventually opted for the more difficult mathematics option at the end of Year 9 (in Finland, mathematics remains compulsory until the end of a student's education, but it is possible to opt for different levels of difficulty), but retained the option to switch to an easier class if she needed to. In addition to social reasons, it is also possible for a students' attitude towards mathematics to vary from lesson to lesson as a result of the tasks that students are asked to undertake. Boaler (1997) observed a number of lessons in two schools. She observed that the nature of the work completed by students had a distinct impact on how they felt about mathematics over time, for example some students reported that they were happier in their mathematics lessons when they were undertaking coursework because they had the time to think, and less happy in lessons where they were answering questions from text books because they felt under pressure to complete questions within a given time.

The OECD (2013) propose that the issue of declining positive attitude towards mathematics is perhaps part of a more general decline in attitude towards school as students mover through their education. Intrinsic motivation is the drive to perform an activity simply for the joy of doing so. The intrinsic motivation of students dissipates as they move from their elementary (in England this is known as primary) education into their secondary education, because not only does work become more challenging, but because as students grow older their interests become more diverse; they are simply less interested in school than they used to be (OECD,2013). This is a position supported by Walls (2009), who quotes one student as saying that he wasn't as strong in maths as he used to be, perhaps because he no longer put the time into it that he used to as his interests had changed. Walls attributes this to the position of students as mathematical people changing as they grew older as a result of the experiences that they have over their years learning mathematics

> "The children's reflections point to mathematical subjectivity as work in progress, as a process of disambiguation in which children remade themselves according to external indicators over their years of learning mathematics" (Walls, p191: 2009)

In relation to mathematics specific enjoyment, the OECD posit that students intrinsic motivation can be damaged by the mathematics that they are learning becoming harder, and also by teaching practices that damage motivation for learning the subject. This viewpoint would appear to be in agreement with Boaler (1997), whose participants reported a more positive attitude towards mathematics when completing tasks in their own time. They preferred working in groups rather than a more traditional didactic mode of instruction, and Bergem (2016) found that varying instructional practices within Norwegian classrooms boosted the attitudes of towards mathematics, and that students were more likely to report that mathematics was boring when asked to do lengthy, similar tasks. It is not possible to tell from these studies at which point in their education students decided that mathematics was “boring”, or that they “don’t like it”, or why in the instance of Boaler (1997) and Bergem (2016) particular styles of instruction had been chosen by the teachers. Martinez-Sierra and Garcia Gonzalez (2017) appear to support this position. They gathered opinions of students in their focus groups in order to gain some understanding as to whether they felt that mathematics was ‘boring’ or ‘not boring’. Participants responded that mathematics was not intrinsically ‘boring’, but this depended upon the style of instruction chosen by the teacher. This is a relatively simple explanation of the vision of mathematics, and could be expanded upon to gather a more complex picture of students’ perceptions of mathematics. Schukajlow et al (2017) conducted a review of the research trends in motivation in mathematics education over the last ten years. From their reading, they note that whilst research interest in motivation in mathematics education has grown, task content and domains should be considered as a direction for future research.

2.5 Unexplored aspects of attitude towards mathematics of students in England

The limitation of these studies is that although they show a little of how attitudes change, they do not use the same instruments, analysis or areas of focus. This means that the areas of attitudes examined, for example anxiety and performance (Dowker 2012), and classroom experiences (Borthwick, 2011), do not provide a complete picture across time. Some studies are limited by age group and as such provide a good investigation of attitudinal factors but not of how students develop these attitudes (Epstein et al 2010, Mendick et al 2007, OECD 2013) for example they provide analysis of how the student has constructed an image of themselves as a mathematician (Black et al 2009, Mendick et al 2007) but not all of the other attitudinal factors examined in this literature review, and the country context in which they are conducted (Smith 2010, Walls 2009). As there is no one study in which all of the attitudinal factors are explored, and because dominance on decision-making of these factors remains unexplored in the current literature it is not possible at the moment to know whether any of these factors are dominant when deciding upon future courses of study. Therefore if my study was to take cross-sections of both primary and secondary school students, using instruments of data collection with the same areas of focus, a more complete and recent picture of how attitudes differ across year groups could be developed. There is not at the moment a longitudinal or cross-sectional study that covers the entirety of students’ school mathematical education in all of the dimensions of attitude considered here.

In this chapter, I reviewed the relevant literature in order to situate my research questions alongside current knowledge, and outlined those gaps in the knowledge that could be filled by the study described and conducted in this thesis.

Chapter Three-Theoretical Framework

3.1 Overview

In order to identify and understand the motivating factors of learners at the point of deciding to study mathematics in post-compulsory education, it is essential to explore existing relevant theoretical notions identifying the key components of attitude. Just as the way in which learning mathematics varies from child to child, and in the same way as learners construct their own understandings of concepts and procedures, they also construct their own idiosyncratic beliefs about and values of mathematics (McDonagh and Sullivan, 2014).

As discussed in the literature review, the research questions to be answered in the course of this study are:

1. ‘Do the attitudes of school students towards mathematics differ at different ages, and if so, how?’

2a. ‘What are the factors which affect a student’s attitude towards choosing to study mathematics in post-compulsory education?’

2b. ‘Which of these are the most dominant?’

In this chapter I examine some of the existing frameworks used to define the notion of ‘attitude’. Firstly, the widely held understanding of the construct of attitude, and how it is understood generally in the fields of psychology and mathematics education will be explored, followed by how attitude can be extrapolated further into ‘affect’. The component parts of affect as they have been examined in the current literature are discussed, considering how the affective dimension, learner self-concept, beliefs about mathematics, and the perceived value of mathematics for both everyday life, and its perceived instrumental value form component parts of affect. I consider how these constituent parts might be formed in the minds of mathematics learners, considering intrinsic and extrinsic factors which might contribute to their formation. Ideas surrounding whether affect and attitude are fixed, or whether perhaps attitudes, values and beliefs can change over time are then discussed. It is necessary then to consider how affect can influence future decisions and actions, completing this chapter with the final theoretical framework which informs the development of the research instruments, and provide the lenses through which I examine the data collected in the course of my study. I explore how existing theoretical models can be combined into a new frame exploring the most salient aspects of affect identified in the literature.

The concept of attitude arguably has roots in both the arenas of sociology, for example the concept that habitus impacts upon the decisions that we make (Bourdieu, 1973), of psychology (Di Martino and Zan, 2009, Eagly and Chaiken, 1993) and in mathematics education (Dowker, 2012, Di Martino and Zan 2009). This study is best placed in the contexts of psychology and mathematics education, meaning that the approaches taken to data collection and analysis will ultimately not use a sociological lens. The reason for this decision is largely due to a lack of evidence that sociological factors exert a significant influence on the decision to study mathematics by learners in England in the post-16 stage of their education

3.2 Attitude towards Mathematics

In order to understand how the attitudes of learners affect their decision to study Mathematics Post-16, it is necessary to define ‘attitude’. There is some disagreement across existing studies as to what “attitude” might be, although research in mathematics education has long been underpinned by a stance that ‘something called attitude plays a crucial role in learning mathematics (Neale, 1969). There is no definition that researchers agree on, and certainly some disagreement on what constitutes “attitudes” (Hannula, 2009), although it is agreed that attitude as a construct needs to be developed further (Di Martino and Zan, 2009, Hannula, 2002, McLeod 1992,). Some studies do not provide a definition of attitude at all, defining it implicitly through the instruments used to measure it (Dowker 2012, Pamapka et al 2011). Pampaka et al (2011) use a four item disposition measure, asking students whether or not they wish to study mathematics after AS-Level, how much mathematics they hope their course at university will involve, the importance of mathematics in their course at university, how they would feel if their course at university involved more mathematics than they thought, and whether they would like the mathematics that they study to be new, familiar or a mixture of the two. They measured whether students would like to study mathematics rather than the thoughts feelings and values that might inform these decisions. In Dowker et al’s (2012) study students were asked to rate how they felt about 7 areas of maths (e.g. maths in general, written sums etc.). They rated themselves in terms of mathematical self-efficacy (“Are you good or bad at it?”), how much they liked it, and how anxious it made them feel.

Teachers may have a different idea again to psychologists and researchers as to what constitutes attitude (Di Martino and Zan, 2009). Teachers often diagnose a “negative attitude” as a reason for a student’s failure, and often perceive it to be global and uncontrollable, rather than an accurate interpretation that can be used for steering future action. In these instances, what the teacher means by “negative attitude” might not be the same across all teachers. For some teachers it might mean “low self-concept”, whilst for others it might mean the students emotional responses towards mathematics (boredom, anxiety etc) (Di Martino and Zan, 2009).

Whilst there is agreement across researchers that even though there is not necessarily one over-arching definition of what might constitute attitude towards mathematics, it is important to understand the impact that it has upon students, their future mathematical attainment (Dowker et al 2012), and on their future disposition to study mathematics and other STEM related subjects (Pampaka et al, 2011). In this section I examine the definitions of attitude offered in psychology, and how these have been extrapolated by mathematics education researchers into definitions and theoretical frameworks that have proved useful for conducting mathematics education research.

3.3. Attitude in Psychology

Di Martino and Zan (2009) argue that the concept of attitude began in social psychology, and that in its earliest definitions, attitude was simply a predisposition to like or dislike, or to respond to an object or concept in a positive or negative way. They note that a key feature of these early studies is that scarce attention is paid to the emotional (“I find mathematics frustrating”) aspects of specific mathematical activities. (Di Martino and Zan, 2009). In agreement Eagly and Chaiken (1993, p1) define an attitude as being a “psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour”. This rather simple definition of attitudes is relatively unusual across researchers. More common is the theory that an attitude comprises a cluster of feelings, emotions, values and ideas (Hogg and Vaughan, 2011). It would appear when examining the existing literature and research that the simple concept of ‘attitude’ is not the correct framework to examine the complex set of feelings, values, influences and anxieties experienced by learners in relation to their mathematical learning. Perhaps the more complex notion of attitude proposed by Hogg and Vaughan (2011) is more applicable when exploring the factors which motivate learners to choose to study mathematics. Fisbein (1967) explores the more complex and varied definitions of attitude observed in social psychology, comparing the work of a number of social psychologists. Many of them support the assertion that attitude is a key component in decision making. In 1905, Baldwin described attitude as a readiness for action. In 1935, Morgan described attitudes as being mental postures, guides for conduct in which each new experience is referred before a response is made. Some of the definitions (Krueger and Reckless, 1931 in Fishbein, 1967, Warren, 1934) clearly relate attitude as a response to previous experiences. Fishbein combines these similar responses into one definition, asserting that “An attitude is a mental and neural state of readiness, organised through experience, exerting a distinctive influence upon the individual’s response to all objects and situations with which it is related” (Fishbein,1967:p.8). Eagly and Chaiken (1993) go on to expand the definition of attitude from their simple first assertion that attitude is an individual’s evaluation of an object as favourable or disfavourable. They go on to discuss how attitude is an acquired behavioural disposition, which could have a biological component as its base, but that evaluation is the critical feature. They assert that attitude is a state which energizes and directs behavior, but they begin to break down attitude into component parts, identifying that attitude has an affective dimension, which means that an individual’s emotions and feelings are a component part of their attitude. The behavioural category of attitude encompasses the individual’s action with respect to an object, but the influences on these evaluative responses consist of moods, feelings, emotions and sympathetic nervous system activity that people experience in relation to attitude objects.

It is perhaps the definition prescribed by Fishbein (1967) that is of most relevance to this study. If attitudes are formed as a response to experiences, then it is reasonable to assume that the collective experiences in mathematics education of a student over time will impact upon the attitude towards studying AS Level mathematics that they will exhibit at the time of choosing their AS Level options. And since Fishbein (1967) and several other researchers (Baldwin, 1905 and Morgan, 1935) agree that attitude has a distinctive impact upon an individual’s response to a new situation, it would appear that definitions of attitude in social psychology would support a theoretical framework which assumes that attitude towards mathematics could be influenced by previous experiences, and that it could be a deciding factor in future behavior, in this instance the decision to study mathematics in post-compulsory education.

3.3. Attitude in Mathematics Education

Researchers seem to be in agreement (De Bellis and Goldin 2006, Di Martino and Zan, 2009, McLeod, 1992, Pampaka et al, 2011) that attitude cannot be identified in the field of mathematics education research as a construct with only a single component. In the Australasian region for example, research in the field has included identity, self-efficacy, anxiety and beliefs about mathematics, with the notion of beliefs in particular being an ongoing area of interest (McDonough and Sullivan, 2014). For this reason, it is necessary to seek a more complex definition. There is a long history of the notion of affect in mathematics education, but again a universal definition is hard to find. Terms used in psychology do not always have the same meaning as in mathematics education (McLeod, 1992). Therefore it is necessary to examine some of the more complex definitions put forward specifically for the purpose of mathematics education research.

The notion of affect towards mathematics is explored in depth by Mcleod in his 1992 paper "Research on Affect in Mathematics Education". He describes the affective domain as being a wide range of beliefs, feelings and moods that are generally regarded as going beyond the domain of cognition (McLeod, 1992). McLeod suggests that beliefs, attitudes and emotions constitute affect. Beliefs in McLeod's model are what a student believes to be true, "Mathematics is based on rules", attitudes are defined as the student's preferences "I like geometric proof" and emotions are defined as the student's feelings, for example joy or frustration. McLeod claims that beliefs are largely cognitive in nature, and developed over a period of time, whereas emotions appear and disappear relatively quickly (McLeod, 1992). De Bellis and Goldin (2006) add a fourth dimension to McLeod's model, making it tetrahedral. They viewed McLeod's model as having three sub domains. The sub domain of "emotion" described a rapidly changing state that was locally and contextually embedded. "Attitude" is a positive or negative disposition towards a concept, beliefs involve an external truth or validity ("Maths is important because..."). The fourth dimension added by De Bellis and Goldin is "values". They define these as personal truths, which might motivate long term choices. Since I am attempting to discover how attitude affects students' decisions to study mathematics post-16, this would seem to be one of the most relevant frameworks, and important dimensions to my particular study.

A simpler definition of attitude is adopted by Pampaka et al (2011). In their 2011 study "The association between mathematics pedagogy and learners' dispositions for university study", close attention is paid to the learning environment and how this might affect students' attitudes. Through surveying the beliefs that teachers held about mathematics pedagogy, and the "mathematical dispositions" of their students, it was ascertained that the students of teachers whose own pedagogical philosophies were "transmissionist", i.e. where teachers and their instructions were the focus of the lesson rather than the students, were more likely to have a "depressed disposition", i.e. less likely to express a desire to study further mathematics than students who took part in lessons where the work was more learner led (i.e. work where students are able to work independently to develop their own ideas). "Attitude" is mentioned several times in this study, and claims made that positive attitudes towards mathematics are currently in decline, and that the drive for standards may be causing a "decline in attitudes" (Pampaka et al, 2011). However a working definition of attitude that the researchers are using in this instance has not been clearly outlined, instead they measure the disposition of students towards studying mathematics in the future. Whilst this usage of 'attitude' is certainly different to those of the other researchers discussed here, (Ma and Kishor, 1997, Di Martino and Zan, 2011), it is a useful consideration in the instance of this study, since one of the research questions addressed here seeks to understand the attitudes towards mathematics that might prevent or motivate a student to study or not to study mathematics in post-compulsory education, and at which point in a student's mathematics education they might begin to form the attitudes and values which will inform future decisions.

Ma and Kishor (1997) decompose attitude into three component parts. The first is self-concept about mathematics, the second is the student's perception of family support and the third is the perception of mathematics as a male domain (Ma and Kishor, 1997). The decision to use these three indicators was based upon the apparent common interest of researchers in these three areas at the time. Whilst this model allows for a more comprehensive view than Pampaka et al's (2011), it is still somewhat limited in its value in terms of how the model as a whole can be utilized in this study, since there is no measure here as to how these parts of attitude affect the disposition of learners to take part in the future study of mathematics.

In their study “Me and Maths” Di Martino and Zan (2009) attempted to find the component parts of “attitude” by asking students to “tell their own story with mathematics through an autobiographical essay. Their study was unique in that they were not attempting to identify how students felt about mathematics, but rather to identify the aspects that students felt compelled to write about as representative of their relationship with mathematics. As such, they did not use Likert style questionnaires, or even open answer questionnaires, they proposed that students write an essay entitled “Me and maths: my relationship with mathematics up to now”. Their hypothesis was that the data collected would allow them to identify the dimensions students themselves use to describe their relationship with mathematics using a grounded theory approach. They identified three component parts, similar to the parts identified by McLeod (1992).

Across the whole sample, only 2.1% of their participants did not refer to at least one of the three dimensions identified below.

An emotional response towards mathematics, for example “I like” or “I dislike”. This response was most visible in the essays gathered from primary school students. Whilst is was visible in the essays of older students, it was mostly used to introduce the reader to the direction that the rest of the essay was going to take.

A perception of capability for example “I can do mathematics”, this is comparable to the notion of mathematical self-concept explored in other mathematics studies (Brown, 2008, Black, 2009)

A vision of mathematics for example “Mathematics is important” or “Maths is hard and confusing”

It appears that from a later analysis of the same data, these three distinct areas of ‘attitude’ are very closely linked (Di Martino and Zan, 2011). In particular there appear to be explicit links between perceived self-competence and vision of mathematics. In their sample, Di Martino and Zan found that students explicitly connect their vision of mathematics with their vision of perceived self-competence, for example “.....I get confused because there are so many rules and theorems” (Di Martino and Zan, p477:2011)

Brown et al. (2007) examined the motivating factors in students’ decisions to continue to participate in mathematics post-16 using a QCA (Qualifications and Curriculum Authority) study evaluating the implementation of the two tier GCSE examination system. In contrast to

Di Martino and Zan (2011), Brown et al (2007) provide no definition of attitude in their study. They do however describe words such as ‘enjoy’, ‘hate’, ‘easy’, ‘excited’ and ‘anxious’ as being “attitude words”.. They appear to examine the attitude of students certainly in terms of their emotional response (“I hate maths”), and perhaps in terms of a perception of ability (“Maths is easy”), however missing from this model is the vision of the importance of maths, and the importance of a student’s ‘leading identity’; a vision of how the student sees themselves (Black et al, 2009). This is discussed in further detail later in the chapter.

3.4 The exchange value of mathematics

In order to make the decision to study mathematics when it is no longer compulsory, students arguably need to perceive some value in its continued pursuit. This can be defined as the exchange value of mathematics, and would be part of Di Martino and Zan’s (2011) ‘vision’ component of attitude. A student might have an instrumental vision of mathematics, perceiving it as a subject which might open doors to them in higher education (Rodd et al, 2010, Black et al, 2009, Rodd et al, 2010), or an understanding that mathematics might be useful to them in the world at large, in their everyday lives. They perhaps might believe that an A-level in mathematics might make it easier for them to gain entrance to a desirable university degree, leading later to a high prestige career, or equally, they might believe that mathematics might be necessary for a career that they already have in mind, for example engineering. Because of these possibilities, and the weight of evidence from the existing studies discussed in the literature review chapter, students’ perceptions of mathematics needs to be addressed in the theoretical framework. This is possible as a part of a more generalized ‘beliefs’ component.

3.5 The categorisation of attitude as positive or negative

In some instances (Ma and Kishor, 1997, Pampaka et al, 2011) researchers attempt to categorise students attitudes into ‘negative’ and ‘positive’. Zan and Di Martino (2007) call this ‘The positive/negative dichotomy’. When they analysed the definitions most frequently referred to by researchers, they found a circularity in the research on attitude and the researchers’ implicit beliefs, or the assumptions that they made about what constituted the construct of attitude. They discovered that when using the simple definition of attitude, for example the definition initially proposed by Eagly and Chaiken (1993), that it was easy to characterise students’ dispositions as positive and negative. When using a multidimensional model, the categorisation of pupils’ dispositions becomes more challenging. ‘Positive’ and

'Negative' can be connected to the different components, but what these two concepts might mean can vary dramatically, and their definition in this context might vary depending upon the observer, and no one component could be considered to have a greater weighting than any of the others. When considering emotions, positive can be interpreted as 'perceived as pleasurable', when considering beliefs Zan and Di Martino (2007) appear to identify that a 'positive' belief is one shared by the experts (for example "Maths is useful"). When referring to behaviour, positive generally means "successful". This means that depending upon the definition of attitude chosen, a 'positive' or a 'negative' attitude could be observed in the same participant. For example the participant could receive a positive score (if their attitude in this instance was measured using Likert instruments) on the emotional dimension ("I like Mathematics"), and a negative score for the belief dimension ("Mathematics will not be useful for my chosen career"). In Eagly and Chaiken's (1993) review of definitions of attitude in social psychology, they observed that Osgood et al (1957) asked participants to rate their attitudes on different scales depending upon the attitude object, for example asking respondents to rate objects as useful to useless, or good to bad. Whilst there are not any examples of this in a mathematics education study, it may be possible to combine responses to different scales, but instruments would need to be chosen very carefully.

Di Martino and Zan (2007) do not assume an a priori definition of attitudes towards mathematics, instead allowing students to express a more general 'relationship with maths'. In a number of pieces of work reviewed in the literature chapter of this thesis, studies focussed on the relationship between 'attitude' and attainment (Ma and Kishor 1997, Dowker 2012, Borthwick 2011), perhaps because teachers on occasion attribute students' poor mathematical attainment to 'poor attitude'. These studies attempted to categorise the students' attitudes into either positive or negative. My research questions are not concerned with attainment, but rather with Zan and Di Martino's (2007) more general definition of 'relationship with mathematics', since to opt or not opt for mathematics in post-compulsory education is not indicative of 'poor attitude towards mathematics', rather of a set of personal beliefs, values and desires, which are not 'wrong' because they do not match my own, or those of other mathematics education researchers, teachers or politicians. In addition, the theoretical model that I have outlined below is rather more complex than simple disposition towards mathematics, so it would become very difficult to attempt to force my readings of my participants' attitudes into 'good' and 'bad'.

3.6. Factors impacting upon attitude

3.6.1. Self-identity

Evidence suggests that self-identity has a strong correlation with behavioural intention. Biddle, Bank and Slavings (2002) found that students who say that they are going to stay in school are much more likely to do so, and that students who identified themselves as "Someone who was likely to stay in school", were more likely to have the intention to do so. Charng, Piliavin and Callero (1988) also found the same to be true of blood donors, with those who said that giving blood was an important part of their self-identity much more likely to go through with the act of blood donation than those who stated that they did not (cited in Terry et al, 1999). In light of these findings, a student having a self-identity as a 'person who is mathematical' is possibly a factor in their decision to study mathematics in post-compulsory education.

Black et al (2009) and McLeod (1992) identify "Leading identity" as an important component of affect likely to influence the decision to study mathematics after compulsory education has ended. The construct is key in understanding student engagement or disengagement with mathematics. Learners do not only have an attitude towards learning mathematics. At the same time, they are developing a sense of self, and beginning to understand how mathematics will fit with this and with their plans for the future. They might perceive themselves as someone who likes to work alone, or as someone who enjoys studying (Black et al, 2009). This appears to be in agreement with McLeod's conceptualization of affect, where it is stated that students hold certain beliefs about themselves that play an important role in the development of their affective responses towards mathematics (McCleod, 1992). This conceptualization is perhaps of importance to my study, since a leading identity of self, i.e. how a student views his or herself, as defined by Black et al (2009) is a likely influence in the decision to continue study of mathematics in post-compulsory education.

3.6.2. Bourdieu's Habitus/Group identity

Since ultimately the aim of this study is to explore whether a student's attitude affects their future decisions to study or not to study mathematics at AS Level, it is necessary to consider what the contributing factors to attitude might be. Bourdieu's habitus explores the idea that the concept of one's place in society will affect future aspirations. Bourdieu's (1976) theory of social reproduction and cultural capital has previously provided a useful framework for studies on the role of social class and occupational aspirations in educational attainment and choices (Dumais, 2002, Reay et al 2009).

The theory of social reproduction has three parts, these are capital, habitus and field.

It posits that the culture of the dominant class is transmitted and rewarded by the education system. In order to be successful in the educational system of industrialized countries, the student needs to have the ability to receive and internalize cultural capital, which is passed down to them by their family, which in turn is largely dependent on social class. Cultural capital is a linguistic and cultural competence that is favoured by the education system (Dumais, 2002). This part of the theory is less relevant to my study than the other two parts, since it is primarily used by Bourdieu to explain students' attainment within the field of education rather than the decisions that they make within it. It implies that because working class students have perhaps not had access to high arts (for example theatre, museum visits or ballet lessons), they are perhaps unable to understand all of the language used in schools, or maybe treated less favourably by their teachers. However, the theory proposes that habitus develops in relation to cultural capital, since it is developed by the available opportunity, structure or field (Dumais 2002).

Habitus according to Bourdieu, is one's disposition which influences the decisions that one makes. It is generated by a combination of factors, including one's place within the social structure. The theory of habitus posits that one internalizes the social structure and one's place in it and will develop practices and explanations accordingly. It impacts upon a student's interest in their education, their decisions to study hard, and their expectations of what they as members of a certain class should be able to achieve, or are capable of achieving (Dumais, 2002).The field is the setting in which the actions of the people concerned are taking place, for example this particular research takes place within the field of education.

As well as being used to explain the attainment of students, the educational attitudes and consequently decisions of students can be examined through Bourdieu's theory of social reproduction using the concepts of habitus and field. When interviewed about their experiences of deciding to enter an elite university, 9 academically successful (in this case academic success was defined as having achieved A grades in their A-Level examinations) students from 'working class families' (where working class is defined as their parents have not attended university, and are employed in a range of manual and service occupations, including car sprayer, child minder, and cleaner), identified a number of occasions when they had been told that university was "not for people like them". Reay et al (2009) propose that this particular set of students displayed an ability to move across the fields of home, where they were loyal to their families and roots, to having "what is seen as a typically middle class disposition towards education". Most of the students interviewed identified that they had begun to develop these attitudes towards education, and this versatility early during their school career. None of the students had access to the high arts that Bourdieu ascribes to cultural capital (Reay et al, 2009).

Dumais (2002) used data derived from the (US) National Educational Longitudinal study to examine the effects of cultural capital and gender on school success. As a part of her study she used the variable of future expectations of employment (what kind of job they expected to be doing at the age of 30 given a choice of professional, managerial, or business; business owner, science or engineering)to investigate the students' aspirations. These were referenced against their parents' occupation, educational levels and, family income in order to assess the impact of the students' habitus upon their future aspirations. She also used students' current educational attainment in terms of their Grade Point Averages (GPA's), and data concerning their participation in cultural activities. She found a significant link between habitus and grades, arguing that higher expectations lead to higher grades, because a student's expectations develop from what she or he has leant in the past, and what he or she believes is likely to happen to people from their particular background. She found that particularly for boys, a disposition towards a prestigious career made them more likely to be achieving high grades (Dumais, 2002). What is unclear from her study, is how social class correlates with the students' career aspirations, and whether the students were achieving high grades because they were working towards a prestigious job, or they decided that they were likely to work in a prestigious job because they were attaining high grades.

Since the subjective norm, discussed later in this chapter, is a global perception of social pressure either to comply with the wishes of others or not, (Armitage and Conner, 2001), and Bourdieu's habitus describes the belief that social expectations have an impact upon educational achievement and choices, Bourdieu's Habitus could potentially explain at least part of the subjective norm, so whilst it will not form part of the theoretical framework used to analyse data, it is certainly an issue of which to be aware. It is not used in this study specifically as the research aims are not to explore the impact of social background upon the decision to study post-compulsory mathematics. This might be a direction for future research.

3.7. The impact of attitude upon future courses of action

In order for this study to be of value in ascertaining the importance of attitude in the decision of students to study mathematics in post-compulsory education, it is first important to understand whether attitudes affect the course of future actions. The examples from social psychology discussed previously in the chapter (Fishbein, 1967, Eagly and Chaiken 1993) would suggest that this is the case, so this is certainly a possibility worthy of further investigation. One such theoretical frame for examining this possibility is the Theory of Planned Behaviour, which is discussed in the following sections.

3.7.1. The impact of attitude upon future behaviour

LaPiere (1934) challenges the assumption that attitudes are a useful indicator of future courses of action. When traveling in America in 1934 with a Chinese friend and his wife he was concerned that his friends might not be well treated, since the attitude of American citizens at the time was perceived as being “negative”. Together with his friends, he visited more than 200 restaurants and hotels. His Chinese friends were refused entry in only one establishment. Six months later, LaPiere wrote to each of the establishments and enquired as to whether they served Chinese guests. 92% of the establishments surveyed responded to LaPiere that they did not welcome any Chinese guests. LaPiere argued that this was striking evidence that there was no strong link between intended and actual behaviour (LaPiere, 1934). This study later went on to become what has been described as probably the most widely cited attitude-behaviour relation study, although the point has been raised that the people who answered the surveys might not necessarily be the same people who served LaPiere and his friends in the establishments that they visited, and that perhaps LaPiere’s friends were not what the proprietors of the establishments pictured when they thought of Chinese people (Fazio and Roskos-Ewoldsen, 2004).

Since then, LaPiere’s findings and subsequent analysis have been challenged in other attitude-behavior relation theories. Researchers argue that the theory assumed by LaPiere, that there was a one-to-one correlation between attitude and action was too simplistic, and that in order to more accurately predict behaviour, more complex models are needed (Terry et al, 1999).

According to Azjen and Fishbein’s (1975) Theory of Reasoned Action, behaviour is determined by an individual’s intention to emit the behaviour. There are two major component parts affecting an individual’s intentions. The first is the personal or ‘attitudinal’ factor. This part according to the theory is a function of the person’s beliefs about the outcomes of performing a behaviour. The second component is the subjective norm, which is an individual’s perception of what people important to them might think about whether the behaviour should be performed. The opinion is weighted by the motivation that an individual has to perform the wishes of those referents. The theory is that a person’s behaviour is determined by her intention to perform the behaviour, and the intention is in turn a function of their attitude towards the behaviour in the first place, and to her subjective norm. The more favourable the attitude, and the more favourable the subjective norm, the more likely the person is to have a strong intention to perform the behaviour in question. In the instance of my study, the subjective norm is perhaps friends, teachers or parents who may influence the behavior of students, in particular to study or not to study mathematics as A-Level. They might have given a student ideas about the difficulty of post-16 mathematics. External influences could impact upon the students understanding of the importance of mathematics A-level for their later career, given that that some students infer the difficulty of the subject based upon what others have told them (Brown et al, 2008). Pampaka et al (2011) suggest that in surveys, teachers' pedagogical attitudes were reflected in the answers of their students to similar questions, going so far as to suggest that a teacher's attitude might be 'transmissionist'; meaning that it could be transferred to students. This supports the idea that teachers have a normative influence, and that the subjective norm certainly contributes a component of a student's attitude.

The Theory of Planned Behaviour (Azjen, 1991) builds on this construct, the addition being that an individual's perceived behavioural control (PBC) will also impact upon their intention to perform an action. The degree of conation in choosing a certain behaviour is influenced by the intensity of the attitudes, which in turn are influenced by the beliefs and opinions of the individual. Whilst Azjen discusses 'behaviours', as a generalized notion of the decision of an individual to do, or not to do something, the action in the instance of my study will be a student's decision to commit to studying mathematics in post-compulsory education. The Theory of Planned Behaviour also suggests that learned behaviours can lead to the creation of new opinions about an attitude object, which in turn can create a new attitude (Raved and Assaraf, 2010). The TPB has been used in numerous sociological studies where the factors that impact upon the intention to perform a behaviour have been examined. Whilst all of the components of the TPB do appear to have an impact upon the intention to perform a behaviour, the effect of each upon the intention is not always uniform (Terry et al, 1999). In a meta-analytical study of 161 sociological studies referencing the TPB, Armitage and Conner (2001) found 185 empirical tests that used the TPB as their theoretical framework. They coded the studies with definitions of components of the theory found, for example tagging references to the "intention component" as 'intention', 'desires' and, 'self predictions'. They then made comparisons between the impacts of each component of theory on the impact on the intended behaviour in each case. They found that in the majority of the studies surveyed the PBC had the biggest impact upon both behaviour and intended behaviour, with the subjective norm having an impact, but to a lesser degree.

3.8. Changes in attitude over time

McLeod (1992) argues that it is possible for attitudes to change over time, and that hardened changes in attitude may have a long lasting effect. He argues that whilst beliefs and attitudes are generally stable, emotions change rapidly. Emotional responses can also vary widely in their intensity (McLeod, 1992). The examples discussed previously from social psychology (Fishbein, 1967, Eagly and Chaiken, 1993) assert that attitude is a product of experience, which would suggest that experiences could change attitude. If experiences can change attitude, and over the course of their educations children have many varied experiences, it would then be reasonable to assume that a student's attitude will change over time.

Assuming the Theory of Planned behaviour to be true, it is worthwhile examining the attitudes of students towards mathematics over the course of their education. Azjen (1991) proposes that an individual's attitude (positive or negative disposition), their subjective norms, and their perceived behavioural control all affect their intention to carry out an action. In the interest of operationalizing the theory for this study, the subjective norms of a person choosing whether or not to study mathematics in post-compulsory education could be their teachers, friends, parents or the mass-media. Their perceived behavioural control would be their mathematical self-concept, which affects their beliefs as to whether they would be able to successfully complete an AS or A-Level mathematics course. Furthermore, according to the theory, new attitudes can be created over time, for example perhaps a student's attitude towards mathematics could change depending upon the pressures of examination in a certain key stage, or with the advent of a new teacher. It is also worth noting that this theory was used successfully by Raved and Assaraf (2010) when investigating the role that the attitudes of high school pupils towards Science education later played in their decision to pursue Science related careers and university courses.

In agreement with McLeod (1992), there are a number of theories that support the assertion that attitude is not necessarily fixed, and can change over time. According to the theory of Cognitive Integration, we perform a kind of cognitive algebra, where new constructs and pieces of information are absorbed, and averaged out with our existing knowledge to form our current attitudes, for example a health warning about a food that we have enjoyed for a long time may change our attitude, and make us decide that we no longer wish to eat it (Hogg and Vaughan, 2011). Attitudes might develop through direct contact with an attitude object (which is something which to which a person could develop an attitude; in the instance of this study the attitude object is 'mathematics'), through interactions with others, or be a combination of these things, along with cognitive processes and thought. Direct experiences provide us with the information to decide how much we like or dislike an object.

"A mildly traumatic experience with an attitude object can trigger a dislike towards it" (Hogg and Vaughan, 2011: p169). This is supported by other theories, for example according to the theory of classical conditioning, a person's attitude towards an object will become more positive or less positive the more they are exposed to it, and the more that the object is paired with either a positive or negative stimulus. In addition, a behaviour is more likely to occur if an individual has received positive consequences as a result of the behavior.

Evidence from mathematics education research appears to support the assertion that attitudes towards mathematics are not fixed and can change over time. Ma and Kishor (1997) found that as students progress through junior and high school years, their mathematical self-concept declines, and also the relationship between self-concept and achievement decline (Ma and Kishor, 1997). Di Martino and Zan agree that in their "Me and maths" study, the student's relationship with mathematics was rarely told as stable.They argue that this suggests that it is never too late to change a student's attitude towards mathematics (Di Martino and Zan, 2009). In agreement, Black et al (2009) argue that a leading identity is a "trajectory", as education and schooling are developmental. Therefore a student's attitude towards mathematics, their leading identity in this model, is likely to change over time (Black et al, 2009). As discussed earlier in the chapter, De Bellis and Goldin (2006) identify that emotion is a sub domain of attitude, and that attitude is a rapidly varying state that depends upon the context that students might find themselves in at the time of feeling the particular emotion.

Since there is an agreement across researchers (McLeod 1992, Hogg and Vaughan 2011), it appears that attitudes are not always stable over time. It is perhaps worthwhile then, to assume that school students might not finish Secondary education with the same attitude towards mathematics with which they started Primary school. This part of the theoretical framework should at least in part provide a lens to examine the first research question, 'Do the attitudes of school students towards mathematics differ at different ages, and if so, how?', as the assumption is going to be that the attitudes of students will change as their time in education lengthens. This premise suggests that the research design should enable the collection of data of how attitudes change over time. This might help to pinpoint events in students' mathematical education that are key to forming their attitude toward mathematics at the end of Secondary education, the point at which they will make the decision as to whether or not to continue to study mathematics after they finish compulsory education.

3.9. Theoretical framework for this study

Since it is so difficult to decide which is the "right" definition of attitude, it is arguable that different research problems might benefit from different definitions, it might be better to ask which is the most relevant definition for the given research questions (Di Martino and Zan, 2009).

In their 2011 Study "Why don't all Maths teachers use dynamic geometry software in their classrooms", Stols and Kriek (2011) successfully combine two theoretical frameworks. Whilst the participants in this study were adults rather than children, it is not the conclusions of their research which make this particular study of relevance to mine. What is worthy of consideration is that the study took place in an education setting, concerned the choices made by individuals, and most importantly combined models of attitude theory in order to answer specific research questions. In order to identify why teachers may or may not choose to use software in their teaching of geometry, Azjen's (1991) model of attitude, subjective norms and control beliefs did not sufficiently allow the researchers to explore the factors affecting the teachers' choice to use the software in their classrooms. This model explains human behaviour in general settings. In order to explore behaviour and planned behaviour in the field of Information Technology, the model needed to be expanded. Stols and Kriek augmented the TPB by adding elements of the Technology Acceptance Model, and the Theory of Innovation Diffusion. In doing so, they created a combined model, which they then used as a framework for analyzing the reflections of their participants on their attitudes towards using the software in their classrooms. The first objective of their study was to examine the behavioural beliefs, normative beliefs and control beliefs on their attitudes, subjective norm and perceived behavioural control. Then, the second objective was to determine whether their attitudes, subjective norm and perceived behavioural control impacted upon their decision to use the software, and then finally, whether or not they actually used the software.Similarly, Terry et al (1999) combined the TRB with the concepts of self identity and group identity to create a theoretical framework for analysing the intentions to recycle household waste with the action of later recycling. Whilst the relevance of a study concerning the recycling behaviours of adults to my study of the education decisions made by children is not immediately apparent, the success of Terry et al's (1999) combined model is worthy of consideration. It is relevant because of its evidence that self-identity in this instance impacted directly upon an intention to perform a behavior, and also that it is possible to combine different theoretical frameworks into one that meets specifically the requirements of the research. In order to identify some of the factors that impact upon a student's decision to study Mathematics Post-16, it is necessary to combine more than one theoretical framework in order to identify the factors, and their relative influences. Whilst the TPB is certainly a useful framework in part for analyzing my participants' attitudes towards participation in post-16 mathematics, as with the research of Stols and Kriek (2011), it does not allow me to explore sufficiently the factors of attitude specific to mathematics learning. I wish to find out whether students' emotional response and vision of the importance of mathematics impact upon their attitude, whether their self and social identities impact upon their subjective norm, and, whether their mathematical self-concept impacts upon their perceived behavioural control. I then need to know whether these factors impact upon their decision to study mathematics, and finally whether or not some of my participants do go on to study mathematics Post-16.

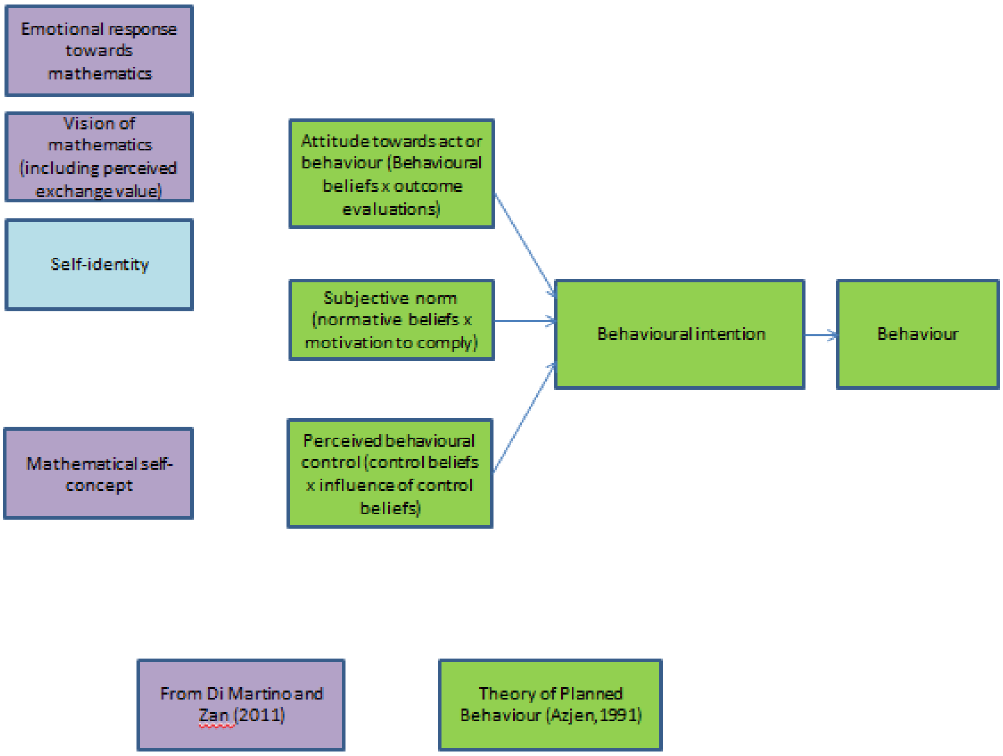
In order to attempt to find the answers to the research questions, I have decided to use a hybrid theoretical model taking the components most pertinent to my research questions from the different theoretical frameworks discussed here. I have decided to do this since no sole framework examined provides precisely a means of examining all the dimensions needed to resolve the research questions. This method of creating a theoretical framework has been used successfully in other studies, for example Terry et al (1999) combined the TPB with self-identity and group identity theories in order to examine the factors most likely to affect recycling intentions and behaviours. Stols and Kriek (2011) combined the TPB with models of behavioural intentions specific to the field of Information Technology usage.

I have chosen the Theory of planned behaviour, because behavioural intention has proven to be a key indicator of whether or not the action will be performed later on (Terry et al, 1999), and is well documented in literature and in practice (Conner and Armitage, 1999). Since the TPB has proven useful in predicting self- reported behaviour, but less useful in predicting the behaviour as proven by other objective sources (Terry et al, 1999), it would be useful to gather data about students' option choices from sources other than their own self-report, this could perhaps be collected from students' option choice forms, or from college destination data after students have left secondary education.

In order to explore some of the influential factors that may inform the attitudes and PBC of students who are choosing their AS level option, I have also decided to use Di Martino and Zan's (2009) framework of attitudes towards mathematics, because these have been quantified as being the key components of attitudes towards mathematics by students when asked to tell their stories of mathematics in their own words. Almost all of the students made reference to at least one of the dimensions of their emotional response (I like or dislike Maths), their visions of maths (Mathematics is important/not important because....) and a perception of their ability (I can do/not do Maths) (Di Martino and Zan, 2009). These dimensions are similar to those identified by other successful models (Pampaka et al, 2011, De Bellis and Goldin, 2006), but have the distinct advantage that in a survey with a large sample size, students across age groups identified these elements in their own autobiographical essays. Since affect, attitudes and beliefs do not appear to be stable across the length of a student's education (McLeod, 1992), a theoretical frame tested with students of varying age groups and abilities would be advantageous. The notion of perception of ability is closely connected with the PBC element of the TPB (Armitage and Conner, 2001).

Finally, I have added constructs which can be used to examine the student's concepts of both self and social group identity. Bourdieu's (1973) habitus has not been included because whilst it potentially plays a role in decision making (Dumais 2002, Reay et al, 2009), there is no particular evidence to suggest that it is particularly applicable to attitude towards mathematics. I do not intend to explore the idea that cultural capital as such plays a role in the decision making processes of students, but the theory that these outside influences have an impact upon decision making would also appear to support the concept that a subjective norm might form an important part of a student's decision making process. Self-identity (Biddle, Bank and Slavings, 2002, Black et al 2009) has also proven to be a key factor in the decision of whether or not to perform a volitional behaviour, in both of the studies cited here the participants were students choosing whether to continue education, and in the second instance participants were students deciding whether to continue with further study of mathematics. The perception of being "someone who is going to do well and go to a prestigious university, proved in a small and determined sample of students to be a more critical factor than numerous social pressures" (Reay et al, 2009). For this reason, I am going to include a student's concept of being "someone who is going to do Mathematics" as part of my theoretical framework. This reflects assertions that the "Leading Identity" plays an important role in decisions about what to study in post-compulsory education (Black et al, 2009, McLeod, 1992). A graphical representation of the theoretical framework can be seen below.

Figure 1- Combined theoretical framework



In the diagram, arrows denote impact upon future courses of behavior, in this case a student choosing to study mathematics at AS-level, and then commencing the course at the beginning of Year 12. The concepts denoted by the green boxes are adopted from Azjen's (1991) Theory of Planned Behavior. The arrows in this part of the diagram indicate that a participant's attitude towards an act or behavior, their subjective norm, and their perceived behavioral control will all impact upon their behavioral intention (their intention to perform a behavior), which in turn will impact upon the participant ultimately performing that behavior. The remaining boxes show the dimensions of attitude that will be adopted as a lens for analysis, and to inform the design of data collection. The colours used here denote the theories from which the components have been adopted, and the positioning the direction of impact upon the final decision to study mathematics in post-compulsory education.

3.9.1 How the combined theoretical framework will be used in the methodology and analysis of data

The combined theoretical framework will be used in the collection and analysis of data. In order to ascertain the impact of attitude towards learning mathematics during their primary school and secondary school education upon participants' attitudes towards the continued study of mathematics at AS-Level or A-Level, questions to assess the attitude of participants towards mathematics in the three dimensions proposed by Di Martino and Zan (2011) are asked in the initial survey, which also includes a number of questions on participants' attitudes towards studying mathematics at AS or A Level and the external normative influences which might impact upon their decisions. The survey then also includes a number of questions on whether they intend to study mathematics at AS or A-Level. The aspects of the theoretical framework discussed here have also been used to design the semi-structured schedule to be used with those participants selected for interview. Once data collection by questionnaire and by interview is complete, then the aspects of the theoretical framework pictured in Figure 1 will be used to tag the data collected from interviews ready for analysis.

Chapter Four -Methodology and Methods

4.1 Overview

In this chapter I discuss the potential means by which data could be collected in order to successfully resolve the research questions. I consider longitudinal and cross-sectional approaches, and their relative merits and disadvantages, as well as the particulars of framing questionnaire and survey questions for children. I justify and problematize my chosen approaches to data collection, arriving at the means by which data was collected during the study.

4.2 Aims of this study

As previously discussed in the literature review and theory chapters of this thesis, this study aims to resolve three research questions:

1. 'Do the attitudes of school students towards mathematics differ at different ages, and if so, how?'

2a. 'What are the factors which affect a student's attitude towards choosing to study mathematics in post-compulsory education?'

2b. 'Which of these are the most dominant?'

The aim of the project is to uncover which factors affect a student's decision to study mathematics in post-compulsory education, which of these are the most dominant, and whether a student's intention to study mathematics will ultimately lead to them doing so. In addition to these aims, this research also seeks to identify how students' attitudes towards mathematics change in the course of their education and why, and at which point they begin to develop the perceptions and emotions that may ultimately lead to their decision to study mathematics when it is no longer compulsory for them to do so. Consulting with children is essential to developing genuinely child-centred policies (Christensen and James, 2008), policies such as those influential in mathematics and general education. If this study is to have further reaching impact, such as the consideration of impact upon education policy, then it is of importance that the views of learners are examined. I consider how best to answer these questions arguing for the use of surveys and semi structured interviews. I discuss why one of these methods in isolation may not be enough to meet the research aims of this project. I consider how best to choose a sample of children to facilitate the most useful data, and the crucial and unique ethical considerations of working with very young children, and young people as they move through their mathematics education is given due thought and attention.

4.3 Philosophy

In order to carry out any research project, it is necessary to first choose the philosophical approach most appropriate to its successful investigation. It is essential to consider this part of the methodological design carefully, since each philosophy has its own associated tools and methods and each influences the way that knowledge is interpreted (Mackenzie and Knipe, 2006). There are three potential philosophical approaches that could be adopted in order to address the proposed research questions; these are positivist/post positivist, interpretivist and pragmatic.

From a positivist standpoint, data collected for the social sciences should be studied and rationalised in the same way as those collected when studying the natural world. It makes use of instruments such as tests and scores in order to quantify the experiences of participants (Mackenzie and Knipe, 2006). A postpostivist approach differs slightly. In this approach, it is recognised that what might be the truth for one person might not necessarily be the truth for another, for example in the context of this study “difficulty” in understanding mathematics might be uncomfortable and upsetting for one person, but for another in the same class difficulty might be perceived as being a fun and interesting challenge. There are a number of advantages to the positivist paradigm. Since I seek to prove or disprove a theory (Burke Johnson et al, 2004), arguably use of this paradigm could produce a quantifiable, more finite answer to the research questions, meaning that I could make generalisations regarding students’ like or dislike for mathematics. Burke Johnson et al (2004) argue that only probabilistic results can be obtained, since education research by definition involves the study of human beings at a given point in time, therefore any knowledge discovered now about factors affecting the attitude of learners towards mathematics might not be true in the future. They also assert that human beings cannot be value-free in their analysis of data collected in this context, so for this reason my study, at least in part should seek to describe the experiences, thoughts and feelings of my participants. Since I was not attempting to prove or disprove any kind of theory, but rather using the components of attitude identified in the theoretical framework as a lens through which to analyse data and frame questions for data collection, an approach that allowed some description of the attitudes of the participants is most appropriate.

In the Interpretivist paradigm, researchers have the intention of understanding the human experience, and of generating new theory (Mackenzie and Knipe, 2006), for example in Di Martino and Zan's (2009) 'Maths and Me', an interpretivist paradigm is adopted to see what the most commonly-used words and phrases to describe students' mathematical experiences are, generating a theory of the component parts of attitude towards Mathematics. Since my research aim was to understand why students feel as they do about their mathematics educations, an approach that was at least partially interpretivist in paradigm has been used. In this paradigm, explanations are generated deductively from the data (Burke Johnson et al, 2004). This element of the paradigm is desirable since the aim of this study is not just to know what factors affect the decisions of different groups of students to study mathematics, but to understand and explain them.

According to Mackenzie and Knipe (2006) the pragmatic paradigm does not align itself with any one philosophical view, but rather is driven by the particular needs of the research questions, and the methods which are best suited to answering them successfully. Burke Johnson et al (2004) contend that researchers need to ask when each approach is most helpful and when they should be combined when conducting studies in education research. It is difficult to align this particular study solely with either the positivist or interpretivist paradigms. It could be argued that a solely positivist approach could have been adopted, since I sought to understand whether attitudes to mathematics change over time, and by collecting quantitative survey data it could have been discovered whether students like or dislike mathematics. However the adoption of this approach would not have enabled me to describe the experiences and attitudes of students, as I could have done if the approach adopted was solely interpretivist. Therefore the approach that was most applicable in this instance was pragmatic. The aim of this study was to discover the patterns of attitude and influencing factors, but also to explain them. The multiple methods approach enabled the researcher to quantify the experience of the participant overall through the administration of questionnaires, but also enabled the description of the experiences, attitudes, thoughts and feelings through the use of interviews with individual participants. The relative merits of the data collection methods associated with both the positivist and interpretivist paradigms are discussed in the following sections together with their limitations. I also discuss how combining the two types of approach maintained some of their features most relevant to answering the research questions, whilst limiting some of their negative aspects.

4.4 Research instruments used

In the following section, the specific research instruments chosen for the study are discussed along with those rejected. The specific rationale for these decisions is presented in each case.

4.4.1 Questionnaires

Using the theoretical framework identified, the component parts of attitude towards learning mathematics to be investigated were: Mathematical self-concept (the student's perception of their own Mathematical capability), their mathematical subjective norm (the people who will influence their decisions when it comes to choosing whether to participate in mathematics in post-compulsory education), their perceived exchange value of mathematics (how useful mathematics will be for their chosen career, and in life in general. This is denoted in the final theoretical framework as a part of vision of mathematics, which impacts upon a participant's attitude towards an act or behaviour) and their emotional response towards mathematics (whether they like or dislike mathematics).The questionnaire includes items designed to gather participants' views on all of these aspects. In order to address the participants' views on all of the identified aspects of attitude, it was also necessary to consider all the component parts of mathematics learning for example mathematics homework as well as classwork.

In order to ascertain some demographic information, my questionnaires begin with a short "about you" section. This section gathers information about the age of the participants in years and months, their gender, and their plans for their future mathematics education.

4.4.2 Likert and Likert Style questionnaires

Likert Scales are instruments of attitude measurement. They are designed to measure not just feelings in one dimension, for example 'like' or 'dislike', but to measure the intensity of feelings about a particular area in question (Bryman, 2008). The items on the scale are presented in order to be a judgment of a value rather than a judgment of fact (Likert, 1932), as such they do not need to be factually accurate, they simply need to reflect a possible perception of the truth. The participants were not assessing the factual accuracy of each item, but were responding to the feelings which the statement triggers in them (Dyer, 1995). In order to respond to the items, participants were asked to indicate on a scale of sigma units (Likert, 1932) with an associated label how much they agreed with the item presented, for example participants were asked to rate how much they agree with the statement "I will study mathematics once I leave secondary school". The ratings which they could then choose from ranged through "Strongly agree", "Agree", "Uncertain", "Disagree" and "Strongly Disagree" with the value "5" being assigned to "Strongly agree", and the value "1" being assigned to "Strongly Disagree". The analysis of Likert scales is unique, and needs to be differentiated from that of Likert-type items. Likert-type items simply make use of the Likert-scale response to allow participants to answer questions. They can be analysed as unique stand-alone items. The questions themselves did not look any different to those in a Likert scale questionnaire. Multiple questions of this type can be used in a survey, but there is no attempt to combine the items into a single composite scale. When making use of an actual Likert scale, the researcher combines several questions, and calculates one composite score from all of these, which is then indicative of a personality trait (Clason and Dormody, 1994). When analysing the data from his survey, Likert (1932) referred to this as the simple method of scoring. The score for each individual was determined by finding the average of the numerical values of the positions that he checked. Since the number of statements is the same for all respondents, the sum of the numerical scores rather than the mean was used.

Likert scales have been used successfully to gather attitude data from respondents of a similar age to those in my study. The 'Faces Pain Anxiety Scale' was used in a survey of how anxious solving mathematical problems made children in an urban school in Melbourne. The scale is often used in medical contexts and has proven to be reliable, with a test-retest reliability of 0.79 over two weeks, and has been used successfully in hospitals with children as young as three, right through to adults. Indeed, Likert scales are routinely used in clinical contexts owing to the low cognitive load that they place onto respondents answering the questions (van Laerhoven et al, 2004). In order to use the faces pain anxiety scale to measure maths anxiety, students were asked to point to a face on a picture scale showing faces becoming progressively more worried. As with a Likert survey, the faces had an associated numerical label, but this time the labels corresponded to the faces being 'extremely worried' to 'not worried at all'. In the primary survey, the word 'worry' was used instead of 'anxiety' as in their pilot study Punaro and Reeve (2012) found that children were able to respond to questions about how mathematics made, or did not make them 'worry', but had more trouble understanding questions as to whether it made them anxious.

Likert scales, and Likert-type scales have been used successfully in a number of studies (Dowker et al, 2012, de Lourdes Mata, 2012, Nicoliadou and Philippou, 2003) in order to measure students' attitudes towards mathematics education. In their study "Attitudes to Mathematics in Primary School Children", Dowker et al (2012) made use of 'The Mathematics Anxiety and Attitudes' questionnaire to assess the attitudes of 89 students in grades three and five in two non-selective primary schools. Their survey focused upon seven dimensions of mathematics: Maths in general, written sums, mental sums, easy maths, difficult maths, maths tests, and understanding the teacher. The same scale was not used for each set of items. Participants were asked to rate their self-efficacy on a scale consisting of ticks and crosses (these were used to indicate ‘Very good’ to ‘Very bad’), their liking for mathematics on a scale of wasps (no one likes those, so this end of the scale represented ‘hate very much’) to sweets (working on the assumption that everyone likes sweets this end of the scale represented ‘like very much’). How anxious they were about mathematics was measured on a scale of facial expressions based on characters from the Mr Men picture books, and unhappiness at poor mathematical performance was measured on a scale of frowning faces (very unhappy) to happy faces (very happy). The possible rating scores on each scale ranged from one to five, so the total possible scores on each scale ranged from five to thirty five. Scores were calculated so that the higher the score, the more positive the attitude of the participant towards mathematics (Dowker et al, 2012). Dowker et al identify a number of limitations that exist in the study. Whilst the questions and method here appear to be generally sound, the nature of the unhappiness at poor performance question is arguably ambiguous here. Whilst being unhappy could be argued to be indicative of a negative attitude, at the opposite end of the scale, being happy in spite of a poor mathematics test score, for example, could be argued to be a negative attitude towards learning mathematics. They also assert that the sample size here is relatively small at 89. The other limitation identified is that one lone survey is not an ideal instrument when working with children. They argue that future studies should include other measures such as an implicit attitude test, behavioural measures such as observing the responses of participants when given a choice between a non-mathematical and mathematical activity, and psychological measures of anxiety, since a large part of this study aimed to measure mathematics anxiety.

The use of Likert, or Likert-type scales in social, and particularly mathematics education research has not been without issue. Ambrose et al (2003) carried out a survey amongst prospective elementary teachers to discover what they believed were the most important factors in students’ learning of mathematics. They identified three issues with using solely Likert-style items in their particular context. Firstly, it is hard to tell what the respondent has understood from the wording of the question. In Ambrose et al’s (2003) survey, when asked to identify what factors were important for mathematics learning, participants were asked to rate on a Likert scale how important it was that a child was a “good listener”. It is difficult for a researcher working with this data to interpret what a respondent understands a “good listener” might be. This is because Likert items offer no scope for a participant to explain what has guided their answers. Secondly, it is impossible to tell from Likert items how important the item might be to the participant. They may respond to the item simply because it is there, but in reality might not consider it to be a particularly important factor. The prospective teachers in this example might consider other factors to be more important in learning mathematics than listening. Thirdly, Likert items in general do not provide a context for the statement that is being posed. In the context of my study, when identifying the people who comprise a respondents' subjective norm, the respondent may believe that his or her parents may be the biggest external influential factor at home, but at school his or her teachers or friends might fulfill this role. Gal et al (1994) agree, posing a fourth issue. They argue that a participants response to a Likert item reveals little about the cause for their answer. In order to identify the issues identified above, I included some free answer questions in my survey, allowing respondents to give some context to their answers whilst allowing me to perhaps understand a little of what the participant has understood from the wording of my question. It also addressed the issue raised by Gal et al (1994), and allowed the participant to perhaps reveal the cause for their response to a particular item. As discussed in the theory chapter, these open answer questions, as noted by Di Martino and Zan (2009) also have the advantage of allowing respondents to express the thoughts and feelings about their mathematics education that they consider to be most important (See Appendix One).

4.4.3 Multiple Methods – Why one method of data collection is not enough in isolation

Since the philosophical approach adopted is pragmatic in nature, it would be inappropriate to collect data which is either purely quantitative or qualitative. The approach to data collection in this study is a multiple methods approach, combining questionnaires and interviews. Research claims are stronger when based upon a variety of different methods (National Research Council 2002). In addition to the surveys completed by larger groups of participants, a smaller number will take part in face to face interviews. It is also important when gathering data with which to examine change over time, individual data are more accurate than macro-level cross-sectional data (Cohen, 2008). For this reason, the inclusion of both the macro-level surveys to understand the general disposition of the cohort towards studying mathematics in post-compulsory education, as well as the interviews to understand accurately the finer details of why individuals may develop these dispositions is advantageous for this thesis. In the following section I describe the benefits of both qualitative and quantitative data collection to my study, and how in using both methods some of the respective short-comings associated with the two different means of gathering data could be addressed.

4.4.4 Interviews as a method of data collection

In the first instance, the initial data collection by questionnaire also provides a platform for choosing interview participants. Once participants have completed the online questionnaire, responses can be analysed and interview participants selected. A representative sample of interviewees can be chosen given the number of students surveyed, which in turn is representative of the population in given cohorts within respective schools, the methodology for this is discussed in a separate section later in this chapter.

Interviews are essential to the process of understanding students' attitudes and what informs these feelings and value, since interviews enable the exploration of context, and may also allow unexpected themes to emerge (Mayall, 2008). An additional benefit of including interviews in the data collection is that they also allow the participants some control over the research agenda, allowing for a more child centred approach, ensuring that themes important to the participants are allowed to be heard. Mayall (2008) also states that analysis of children's own understandings are important for considering what policies are appropriate to leading satisfying lives. If this is assumed to be true, then allowing students to discuss how their mathematics education caused either satisfaction or dissatisfaction might reveal how Year 11 students arrive at the decision to either study, or not study mathematics in post-compulsory education. If I were to have restricted data collection to purely quantitative methods, for example only the questionnaire, analysis would have been limited to the components of attitude identified in the theoretical framework. By adding the qualitative interview element of data collection, I was be able to identify and code any themes which were not identified in the theoretical framework that were identified as being important by the participants.

Interviews have a number of distinct advantages for gathering the kind of deeply descriptive data that I am interested in. Information can be gathered in great depth, and by using skill and understanding, the interviewer can overcome issues as they arise, for example by clarifying points with participants. There is the flexibility to re-structure the questions to help understanding, which is particularly important when gathering data from children, as the questions might need to be re-phrased to reflect the educational level of the participant (Kothari, 2004). Interviewing participants has a number of benefits associated with qualitative data collection. From gathering qualitative data in this way, it was possible to demonstrate vividly the thoughts and feelings, and ensure the validity of questions in my survey since participants had the opportunity during the interview stage to demonstrate their understanding of the constructs they were questioned upon during the survey stage. This was an advantage since the survey alone does not give such an insight, for example it is not possible to tell what a participant's understanding of "I am good at Maths" might mean. Whilst I was not actually exploring different meanings, it was important not to assume any one meaning, since my understanding and the understanding of participants could have been different, which might have then affected how data were analysed. One significant advantage of interviews is that they enable the researcher to identify factors in the local setting that relate to the area of interest (Burke Johnson et al, 2004). The implication for my study was that I was able to identify some of the factors in different school settings, for example as pupils moved through key stages, or from pupils in the same key stage in different classes that have affected students' attitudes towards mathematics. The most significant advantage of this kind of qualitative data collection is that they enable the description of complex phenomena, and of participants' actual experiences (Burke Johnson et al, 2004). Whilst the questionnaire data alone might have provided insight into how student bodies feel as a whole, it would be less useful in identifying the events thoughts and feelings as they were experienced by the individual participants.

Whilst interviews have a number of clear strengths, they also have a number of weaknesses. In a purely qualitative approach, the knowledge produced might not generalize to other settings (Burke Johnson et al, 2004), meaning that in this study the experiences of the relatively small number of students interviewed might not be representative of the experiences of students in general. They might also have been influenced by my personal biases in my analysis and in my questioning. They are expensive in the time that they take to conduct, both for the interviewer and for the participants. For these reasons, a purely qualitative approach was not appropriate for answering the research questions. However, the inclusion of a quantitative approach directly addresses these issues. Burke Johnson et al (2004) also identify some of the strengths associated with quantitative methods. One of the most relevant to my study is that quantitative methods are useful in gathering relatively large samples of data quickly. Their analysis is relatively quick in comparison with data gathered through qualitative methods such as interviews. The questionnaire section of the data collection enabled the gathering of data that was more easily generalised than that gathered in interviews, since the corpus of data would be so much larger than the much smaller number of interviews that I conducted.

4.5 Selecting samples

Sample sizes in the studies referenced earlier in the literature review of this chapter are relatively large. West et al, (1997), used 290 very young students aged just 6-7 years old, asking them to give their views on a range of school experiences from how much they enjoyed coming to school, to how much they enjoyed specific classroom activities, such as being read a story, or taking part in Science experiments. They gave their views by colouring faces on the 'smiley scale', which was explained to them in small groups by a researcher. Following this initial survey, 34 children were selected to be interviewed in more depth by the researchers. Dowker et al (2012) used a sample of 91 children who completed questionnaires. Ruffell at al (1998) used a somewhat smaller sample of 31 year 6 children. Bryman (2006) asserts that the relative size of a sample is not important, but rather the absolute size, giving the example that 1000 participants in a study of America is not a less reliable sample size than 1000 participants in a study in the UK. Therefore there was no set proportion of the total population of the schools used in this study.

4.5.1 How were interview participants chosen?

In order to choose the participants for the interview stage of data collection, probability sampling was used to choose 10 random participants per year group. Five from those who identified that they do wish to study mathematics in post-16 education, and five from the group who have identified that they will discontinue studying mathematics once their GCSE examinations are complete. When the sample was chosen, a proportionate number of boys and girls representative of the number of each in the whole year group cohort was selected, but this was secondary to ensuring that numbers of those who had opted for and not opted for mathematics. No one participant from each group will have a greater chance of being selected than any other. According to Bryman (2008), it can be assumed that using probability sampling in this way should guarantee a representative sample of the population. Those who returned the consent forms then participated.

4.5.2 The respective ages of participants in this study

The selection of age groupings in the study is cross-sectional by design; the reasons for this choice are discussed later in this chapter. Students were selected from across school key stages. Sampling participants in this way allowed the gathering of data across the entire experience range of students. I decided to divide my data collection by key stage since the curriculum in schools in England is divided into distinct sections by key stage, with each section bringing new knowledge, new pressures such as exams and formally reported teacher assessments, and changes in school in the instances of students moving from Key Stage One to Key Stage Two, and those moving from Key Stage Two to Key Stage Three. With the exception of key stage two, all the Key stages have a roughly even amount of time passing between them of around two years. The first group of children surveyed was in Year 2, the final year of Key Stage One. This age group was selected for inclusion in the study as they had completed the first formally taught year of their education, and were able to reflect upon how they have felt about their first formal encounters with number. As seen in the literature review, mathematics education research with this particular age group remains limited, perhaps owing to difficulties collecting data from children at this age. Since Key Stage Two is the longest of the key stages, participants were surveyed and interviewed from Years 4 and 6, the middle and final years of the key stage. Students in secondary school were surveyed and interviewed in Year 7, the beginning of their secondary school education. The next group sampled were in Year 9. In the secondary school which participated, the students were in the first Year of Key Stage Four. The final cohort of secondary school students participated during Year 11, the final and perhaps most important year of their secondary school education. This is the year when students take their GCSE examinations, and make decisions about which sixth-form colleges to attend and which courses to study at AS or A level. This cross-section of participants represents the whole age range of students in secondary schools in England, so the sample will include students who are currently experiencing, or who have recent memory of significant events at each stage, for example GCSE examination preparation or changes in key stage.

4.5.3 How schools were chosen to participate in this study

One secondary school, one infants school and one junior school were chosen to participate in this study. They were all in the same locality, but not the same catchment area in a semi-rural part of Hampshire. In order to recruit schools, the headteacher of each school was approached by email to ask whether they were interested in their school taking part in the study. They were then provided with information regarding the data collection instruments to be used in the part of the study appropriate to their school, together with consent forms required, and participant information sheets for both students and their parents. Providing the questions to the school ahead of scheduled interview and survey completion has some implications for the validity of the data collected, but was necessary to ensure that the headteacher is giving his or her informed consent to his or her students participation in the study. Without understanding what questions will be asked of participants, the headteacher could not have been reasonably expected to make an informed decision as to whether participation in the study is in the best interests of their school or their students. It was made clear to the headteacher that survey and interview questions should not be made available to participants or their teachers ahead of their scheduled implementation. This measure is necessary to ensure that participants are free to give their honest answers and opinions free from any coercion by external influences. They were also offered the chance of a face-to-face discussion in order to ask any questions arising from their perusal of the materials. None of the headteachers had any concerns regarding the data collection. The schools chosen for participation in the study were already using student-voice activities, for example forums, group interviews and surveys as a means of schools self-evaluation. This ensured that a culture of asking students for their honest opinions has already been established, as a result of which students were comfortable and confident expressing their feelings and opinions to adults, and in front of their peers.

4.6 How were adequate sample sizes ensured?

A number of steps were taken when collecting data from each Key Stage in order to ensure a reliable sample size. The procedure is outlined below for the steps taken at each research site.

At Key Stage One the researcher visited the site in order to liaise with the teacher in charge of administering consent forms and recruiting interview participants. Regular email contact was maintained with the teacher in charge with regard to the numbers of permissions slips returned by students.

When ensuring an adequate sample size from Key Stage Two students, a slightly different approach was taken due to the different ways in which data was collected. Prior to the online questionnaires being administered, regular email contact was kept with the school in order to ensure that permission slips were being returned by participants. Once online data collection had begun, the response rate was monitored. Reminder emails were sent to the school in order to ensure that as many responses as possible were collected. Following the selection of interview participants, again email contact was kept with the teacher in charge of data collection, who in turn reminded class teachers to check that permissions slips were returned. Class teachers then reminded students in lessons, and parents when they saw them after school.

At Key Stages Three and Four following the initial distribution of participant information sheets and letters to the school, the researcher checked the numbers of completed questionnaires completed online on a daily basis. Regular contact was maintained by email with the teacher in charge of distributing and collecting participant consent forms to keep her updated on the numbers of complete questionnaires. She reminded classroom teachers to ask their students for permission slips, and reminder notices were sent out through the school bulletin (which meant that students were also reminded by their tutors in tutor time).

This process for ensuring adequate numbers of participants was also followed for interview participants.

4.7 Data collection in Key Stage One-First formal encounters with number

Data collection with the Key Stage One cohort needed to be different in design to that used with other participants in the study, due to the age of the participants. Existing research with children of this age group is more limited than that with other cohorts, perhaps due to the unique difficulties in working with participants of this age. Language use, literacy, and children's stages of cognitive development all pose difficulties for data collection with very young children (Scott, 2008). Since the literacy skills of participants might not be equal to the level needed in order to complete a Likert-style questionnaire, and certainly not to writing long answer responses to open questions, these instruments were inappropriate. However, the questionnaire shares several characteristics with the structured interview (Bryman, 2008). For this reason, semi-structured interviews were used including questions similar to those included in questionnaires. In order to ensure that the questions are accessible to the children, adaptations were made to those designed for use with older participants. The number items in the questionnaire was reduced, since children of this age are used to working in short bursts, and a longer interview may not hold the attention of the participants (See Ethics Approval, Appendix One). This also ensured that they were not removed from their lessons for too long. In addition, a number of visual prompts were used to help elicit answers from the children. These prompts correlated with the items on the Likert scales used in questionnaires with older participants, although in order to reflect the age of the participants, and reduce confusion only three possible responses were provided. When Year 2 children were asked to choose whether they like, are indifferent to, or dislike numeracy they were asked to choose between graphical representations of the concepts, for example in Dowker's (2012) paper survey with slightly older children, participants could choose wasps if they disliked a concept, or sweets if they liked it. Scott (2008) agrees, citing that pictorial prompts are useful, and make concepts more concrete to younger children than discussion alone, and that simple Likert responses such as those described here can be used with young children with prompting, however young children may find it difficult to distinguish between what is said and what is meant.

Since the children were so young, the power-balance between interviewer and participant cannot be ignored. Careful steps were taken to ensure that the participants in this part of the study feel happy and confident taking part. Berry Mayall (2008) conducted a study including children aged 5-6 which gathered the opinions and feelings of students about health. She carried out this study in the students' regular classroom, meaning that the children were not forced into a strange situation, in this case being interviewed in a room with which they weren't familiar, by an adult that they didn't know. She also suggests that asking children to choose a friend to take part in the interview with them also helped the children in her study to feel at ease. In order to ensure that the youngest participants in my study were comfortable with the process, they were interviewed in a classroom familiar to them. They weren't interviewed in groups since this raises issues with the validity of data collected, since participants responses may reflect those which they perceive their friends to consider socially acceptable (Bryman, 2008). Since these interviews involved participants responding to visual prompts, the interviews were recorded and then transcribed. The transcripts were then be tagged and prepared for analysis in NViVO using the same categories used in preparation of the interview and open answer survey data collected from older participants. A conceptually clustered matrix was built using the tags. This is discussed further with the resultant codebook in the Key Stage One Analysis Chapter.

4.8 Data collection in Key Stage Two

Since Key Stage Two children should have a higher level of literacy than those at the end of Key Stage One, participants at this Key Stage completed an adapted version of the questionnaire that has been designed for Key Stage Four participants. The questionnaire comprised Likert items and concluded with some long answer questions so that participants could provide some illustration as to why they felt the way that they did about mathematics. When creating Likert items, the 'One end' of the scale is always assigned to the negative of the sigma scale, and the five end always to the positive (Likert, 1932). I have applied this to my questionnaire by assigning a value of one to 'Strongly disagree', and a value of 5 to the opposing end of my scale, with 'strongly disagree' as the associated verbal label. In the survey designed for secondary school students, I made use of a sigma scale with associated textual labels, since this is well trialed as an effective measure of attitudes in children aged 8 and above (van Laerhoven et al, 2004). It has been proven on multiple occasions that primary and middle school students are also able to work with the concept of a Likert scale, but perhaps not the sigma scale and associated labels (Punaro and Reeve, 2012, Dowker et al, 2012). In order for students aged 8 and below to respond to the questions, and indeed since the 'faces pain anxiety scale' has been used in clinical contexts with patients as young as three (Punaro and Reeve, 2012), a pictorial scale was used in order to gather survey data from younger students, using faces to represent the points on the sigma scale. The faces range in expression from sad for 'disagree a lot', to happy for 'agree a lot'. Despite their widespread use in social research, there is little agreement between researchers as to the optimal number of possible responses to allow on Likert scale responses (Alwyn et al, 1997). I have chosen to include a mid-point possibility on my scales to allow users to indicate a position of neutrality. I have chosen a five point scale for the Likert-style questions to allow for finer distinctions between points on the scale than would be possible if a three point scale were to be used. This is comparable to the approach taken by Dowker et al (2012), with their five point scale of sweets (like very much) to wasps (Hate very much). The questionnaires were completed in school using the computers that were already present in the classroom that the participants were in every day. A link was emailed to the headteacher together with the username and password for the questionnaire.

4.8.1 Interview question design

For participants in Key Stages Two, Three and Four, semi-structured interviews comprising fourteen items were conducted. The interviews will begin with a short introduction to the researcher, and participants had the chance to ask any questions. They were also asked if they were happy for the interview to be audio recorded. The interview (the semi-structured schedule for which can be seen in Appendix Five) began by asking students to reflect upon their answers to the online questionnaire (The questions for which can be seen in Appendix Two). The following questions then comprised items designed to encourage participants to discuss not only their thoughts and feelings about their mathematics education, but the reasons why they feel as such, such as whether they have always enjoyed (or not enjoyed mathematics), and why they might feel that mathematics is important (or not) for any career aspirations that they might have; for example ‘How important do you think that mathematics will be for your chosen career? Why?’ and ‘How important do you think mathematics is for your life now and after you leave school outside of work?’

At the interview stage, since the interview was semi-structured participants had the opportunity to discuss any factors that they feel have influenced their attitudes, for example they were asked at the end of the interview whether there was anything that they felt that it was important for me to know about how they or other learners in England perceive mathematics. Interview participants were interviewed in a work room with a glass window adjacent to the headteacher’s office in order to satisfy safe-guarding requirements for lone working with children.

4.9 Data collection in Stages Three and Four

Groves et al (2009;p.2) assert that a survey is a systematic method of gathering information from a sample of entities for the purposes of constructing quantitative descriptors of the attributes of the larger population of which the entities are members. In order to construct descriptors which are representative of the wider student population, this study made use of mixed attaining IT classes in which students have already been placed by their schools, since the external validity of cross sectional design is strongest when the sample is chosen at random (Bryman, 2008).

Participants were invited to complete the questionnaire comprising Likert-styles and open answer questions. The questionnaire includes 39 Likert-style items, and 3 open answer questions respectively. In order to minimise bias, an equal number of favourable ('I like mathematics') and unfavourable ('Mathematics is boring') items have been included (Batcho et al, 2010). The survey can be seen in Appendix Two. The survey was administered online, and the link to the survey was emailed to the participants using their school email addresses, since all communications to and from this address are monitored by the school network administrator ensuring the safety of both participants and the researcher. Open answer questions were tagged in NViVO according to the themes identified in the research questions, and prepared for analysis using a conceptually clustered matrix created in Microsoft Excel. Further discussion of this can be seen in the relevant analysis chapters together with the resultant codebooks. Once participants had completed the online survey an initial analysis of the responses was carried out in order to select a sample of interview participants. Interview participants were selected to represent the range of attitudes towards mathematics across the cohort, as well as a representative as possible sample of boys and girls who had completed the questionnaire. Since many students of this age were likely to have thoughts about which subjects they would like to study in post-compulsory education, particularly those in Year 11 who had already applied to Sixth-form college, representative samples of those who have expressed a desire to study AS Level mathematics, and those who have decided not to were selected. The participants selected then completed the semi-structured interview. Key Stage Four participants were interviewed in the IT staffroom which was connected to one of the IT classrooms. This meant that the setting in which interviews were conducted was at least partially familiar to them, and ensured that no lone-working with students was necessary which was important for safe-guarding reasons.

In total 171 participants contributed to the study. The breakdown of participants by Key Stage and year group can be seen in Table 1 below. These are then broken down further by gender in Table 2, and by whether they participated in online questionnaires or in interviews.

Table 1 – Breakdown of participants by Year Group

Key Stage	Online Questionnaire	Interviews
Key Stage One (Year 2)	N/A	22
Key Stage Two (Year 4)	23	6
Key Stage Two (Year 6)	31	6
Key Stage Three (Year 7)	44	7
Key Stage Four (Year 9)	29	4
Key Stage Four (Year 11)	22	5

In order to ensure accessibility of data collection for participants different methods of data collection were used in different Key Stages, and in some instances the same method of data collection was used with some adjustments.

Because the participants in the Key Stage One sample were so young, a semi-structured interview was used without an online questionnaire. This was because they may not have been able to read all of the Likert items to themselves. This may have led to the data collection taking more time than would be acceptable ethically. It also may have meant that they would have needed an adult to read the questions to them, meaning that a teacher or teaching assistant might have had to sit with each participant and read it to them, taking them away from the necessary business of the classroom.

Because participants in Key Stages Two, Three and Four were more likely than Year 2 students to be able to use a computer confidently, and to read the questions themselves an online questionnaire could be administered. Questions in the Key Stages Three and Four questionnaire differed slightly to those in the Key Stage Two questionnaire. Questions which made reference to GCSE grades were not present, and some vocabulary adaptations were made e.g. 'I know what my chosen career will be' in the Key Stage Three and Four questions became 'I know what I would like to do for my job when I grow up' in the Key Stage Two questionnaire. It was then possible to select participants for a semi-structured interview similar to that used with those participants in Year 2. Again, some adaptations to questions asked of Key Stage One students were made e.g. including an explanation of what A-Levels are.

The chronology of the data collection, as well as the methods of collection and analysis can be seen in Table 2 below.

Table 2 – Chronology of data collection and means of collection and analysis at each stage of the project

Data Collection or Analysis?	**Data Collection Instrument**	**Data Analysis during data collection, and final analysis carried out once data collection was complete**
Data Collection KS1 participants	Interview (22 Participants)	
Data Analysis KS1		Tagged and analysed using NViVO and Excel
Data Collection KS2 participants (54 participants; 23 Year 4, 31 Year 6)	Questionnaire	
Data Analysis KS2		Data analysed using Excel Identification of interview participants
Data collection KS2 participants (12 participants; 6 each from years 4 and 6)	Semi-structured interview	
Data Analysis KS2		Data tagged using NViVO and analysed using SPSS and Excel

Data Collection or Analysis?	Data Collection Instrument	Data Analysis during data collection, and final analysis carried out once data collection was complete
Data Collection KS3 and KS4 participants (95 participants; 44 from Year 7, 29 from Year 9, 22 from Year 11)	Questionnaire	
Data Analysis KS3 and KS4 participants		Questionnaire responses analysed to find participants for interviews
Data Collection KS3 and KS4 participants (16 participants; 7 from Year 7, 4 from Year 9, 5 from Year 11)	Semi-structured interviews	
Data Analysis KS3 and KS4 participants		Data tagged using NViVO and analysed using SPSS and Excel

4.10 How the changing attitudes of students over time was examined

In order to address the research question “How do students’ attitudes towards Mathematics change as they progress through their Mathematics education” it was necessary to design a data collection tool that could be used to collect the changing nature of students thoughts and feelings. In this section of the methodology, I consider how three different methods of collecting such data could be utilised; longitudinal data collection, cross-sectional data collection, and collection of data through retrospective surveys. I consider their attendant potential benefits and limitations.

A longitudinal study involves taking people in the same age cohort and gathering data at various points in their lives (Bechhofer and Paterson, 2012), a cohort being defined as a group of people within the same age range. They are then followed for as long as the study is carried out, which might mean for as long as participation is available or for as long as intellectual curiosity continues. Longitudinal studies have the advantage of allowing the identification of causal influence, providing the researcher with a timeline upon which they are able to determine which events (causal influences) might take place during the period of data collection. The advantage for this study is that it would have become possible to create a linear record of significant events in the mathematics education of the children and the impact that these events have in shaping the attitudes which may lead to them ultimately deciding to study mathematics in post-compulsory education. This longitudinal approach to data collection might have allowed the researcher to better determine the ages at which participants' attitudes might change towards mathematics and why. In order to capture the changing feelings, interests and attitudes of students, the same participants could have completed further questionnaires one year after they take part in the original data collection. The questionnaires on this occasion could have included the original Likert-style questions. The open answer questions on this occasion could then have been adapted to include items to measure the impact of events in the lives of the participants in the following 12 months will have had on their attitudes and feelings towards mathematics. These questions might have been useful in discovering whether there have been any significant events in the mathematics education of the students, for example band changes, major examinations or changes in class teacher. I could have asked them to reflect on the mathematical journey of the past year, and in the cases of Key Stage Three and Four participants whether or not their intentions to study mathematics in post-16 education has changed. The original interview participants could then theoretically have been reinterviewed with an amended set of interview questions seeking to discover whether their attitudes to mathematics have changed in the last year and why. A representative sample of students who have identified themselves as feeling differently towards mathematics could also have been interviewed in order to give some more context into why they feel that their attitudes have changed.

For the very youngest students, a new video interview could then be conducted. The same semi-structured approach could be taken, with additional prompts for example asking them to think about what new concepts they have learnt in numeracy, and whether they thought that the new concepts were fun. However, this research design would be particularly problematic in the context of this study. In essence, the whole data collection is carried out twice. This poses logistical and ethical issues. In order for this method to be used, a considerably greater burden is placed upon participants and their schools. In order for a study to be ethical, it should not place an unnecessarily large bureaucratic burden on those taking part, or increase their workloads more than necessary (BERA, 2011). This method of data collection would mean that participants would need to take the time to complete questionnaires and interviews twice, whereas if the study were to be solely cross-sectional by design, data of the same quality and usefulness in answering the research questions could be collected. In addition to these issues, longitudinal studies can be expensive to carry out in terms of money (Bechhofer and Paterson, 2000). It can also be very difficult to keep in touch with the participants, and persuade them at intervals to take part in the study, for these reasons, these methods are little used in social research (Bryman, 2008). They are sensitive to attrition, for example in Menard's 1992 adolescent drug use survey, 55 per cent of the participants were lost over the eight years in which it took place. One major issue with attrition is that the participants lost from my study might not share the same characteristics as those remaining. This would be particularly problematic in the case of interview participants. Additionally, it may not be that a longitudinal design, particularly when interviews are to be used as a method of data collection, may not gather the most accurate data when compared to cross-sectional methods. Cohen (2011) cites the measurement effect as an influence upon interview participants. If interview data were to be gathered from participants as they moved through their schools, the measurement effect could potentially influence the behavior that the participants exhibit.

Buck et al (1995) and Solga (2001) propose retrospective surveys as an alternative to the longitudinal model. In a retrospective survey, participants are interviewed only once, and prompted to recall events in their past. They are advantageous in their simplicity and cheapness, and provide immediate access to longitudinal data. They are not vulnerable to attrition (Solga, 2001) in the same way as longitudinal research. Participants recall of significant events is likely to be good, for example in the context of this study events such as changes of teacher, key stage or important exams would be likely to be fairly accurately recalled. However, the validity of using retrospective surveys as a sole means of data collection is questioned by some researchers, some argue that It is improbable that people will remember facts about themselves after a passage of time (Bechhofer and Paterson, 2012). The description of past events is dependent on the recall of participants (Solga 2001), which in the instance of people recalling childhood events might be somewhat romanticised, since childhood memories are sensitive to selective retrieval and reconstructive bias (Batcho et al, 2010), meaning that students who enjoy mathematics now may remember their attitudes and experiences always being positive. However, the purpose of this study was not to reconstruct events from the memories of the participants, the research aim of this study was to discover how the attitudes of children towards mathematics change over time, and how these attitudes at the point of selecting options for A-Level might lead a student to either opt, or not opt for mathematics. Batcho et al (2010) also argue that the interpretation of new situations can be affected by whether experiences in one's past were helpful or debilitating, therefore whilst perhaps as a tool of gathering longitudinal data retrospective surveys are perhaps not the most reliable means, it is worth including some questions in participant interviews about how participants remember their experiences, perhaps giving some insight into how their current attitudes have formed.

Bryman (2008) describes cross-sectional research as data about more than one variable being collected at a particular point in time. Similarly cross sectional data collection can be defined as data from a cohort being gathered at one particular point in time (Bechhofer and Paterson, 2012). Whilst cross-sectional design is often called survey design (Bryman, 2008), it could involve instruments such as questionnaires and structured interviews, but in order to establish variation between respondents there needs to be some kind of systematic and standardised way of gathering data. Cross sectional studies are relatively quick and cheap to carry out, and have the advantage that because data is gathered at one point in time, participants are less likely to be lost to attrition. The cross sectional design was valuable since it allows links to be made between variables, for example the link between students' key stage in their education, and their respective attitudes and beliefs towards mathematics. An additional benefit of the cross sectional design is that validity, reliability results achieved using this method are little different to those of the longitudinal method, but are significantly less costly and difficult to administer (Bryman, 2008). Since the use of a cross sectional design for this study meant that the data gathered is of similar quality to that which could be gathered in a longitudinal survey, but was less costly in terms of both my time and that of my participants, there was little advantage in employing a longitudinal method. Therefore a cross-sectional approach to investigating how the attitudes of children towards mathematics changes over time was adopted. Participants were organised into cross-sections by their respective key stages, and complete the questionnaire, and in some cases interviews, appropriate to their key stage once. Data gathered from the different cross-sections were then analysed and compared in order to make comparisons between participants' key stages in education, and their attitude towards mathematics. Since Key Stage Two is four years long (which is longer than any other Key Stage), students from Year 4 and Year 6 participated in the study.

4.11 Data analysis methods and procedure

Once data collection using iSurvey was complete, the questionnaire data was transferred to SPSS for statistical analysis. This was repeated for data collection both at Key Stage Two and Key Stages Three and Four. The units on the Likert scale used for the questionnaire were converted to numerical values, with a value of "1" being assigned to the "strongly disagree" statement, and a value of "5" being assigned to the "strongly agree" statement. Pearson correlations were then used to establish relationships between attitudinal factors, and the desire to study, or not to study mathematics in post-16 education. When drawing Pearson correlations, correlations become stronger the closer they are to a correlation of "1", so a Pearson correlation of .775 is a much stronger correlation of .335, which could be considered to be relatively weak. Since the Likert-style questionnaire utilises a sigma scale whereby 1 in the lowest score that can be assigned (denoting that a participant strongly disagrees with a statement), and 5 is the highest score (denoting that a participant strongly agrees with a statement), Pearson correlations could then be used to draw comparisons between different factors, for example as the combined scores of participants agreeing with the statement "I will study mathematics after secondary school" become higher, so too might the combined scores of participants agreeing with the statement "Maths lessons are fun". In this instance a positive correlation could be drawn between the two factors. Conversely, negative comparisons have also been drawn, for example as participants agree more with the statement "I will not study mathematics once I have left school". In order to investigate the components of attitude which are most dominant in the decision to study, or not to study mathematics in post-16 education, a question from each of the attitudinal components outlined in the theoretical framework has been compared with the intentions of studying, and not studying mathematics. A comparison of the strongest Pearson correlations has then been made.

In limited instances, mean averages have been used to analyse data. At the beginning of the survey, students are asked "Do you intend to study mathematics after secondary school?" Since this question is only answered with a "yes" or "no" response, Pearson correlations were not a suitable means of analysis. In order to use this data, the "yes" and "no" values were converted to "1" and "0" values respectively. This was useful for example when comparing year group to the intention to study, or not to study mathematics, since means using the total participants in each year group could used to calculate average ambitions to continue studying mathematics post-16.

Interviews were audio-recorded and transcribed. Once the transcription was complete, then the transcripts were tagged in NViVO using the component parts of attitude, and other influential factors identified in the theoretical framework. The tagged transcripts were then used to organise the interview data by the component parts of attitude. The evidence drawn has been discussed and used to illustrate participant attitudes towards mathematics in the dimensions of those themes identified in the theoretical framework, and those themes most prevalent in the quantitative data drawn from the questionnaire analysis.

Further explanation of analysis is provided where necessary in the following chapters.

4.12 Ethical considerations

This study was conducted in accordance with the University of Southampton ethics policy for studies involving human participants. The proposed research was submitted for scrutiny using the University's ERGO system, and carried out with the highest regard for ethical research practices, and in the best interests of the participants. The Ethics submission and accompanying forms and information sheets can be seen in the Appendix One.

Researchers should consider the nature of their participants capabilities to give informed consent. This is both good research practice, but there are also significant knowledge gains when a child's active participation is sought, and their views and feelings are accepted as genuine, valid evidence (Christensen and James, 2008). Participants should be informed of any consequences or dangers that could arise from their participation in the research, as well as any benefits to them and should be made aware of their rights to withdraw their data from the study up until the time of publication, or to refuse without any further questioning to take part. They should receive a fair description of the procedures which are to take place (Cohen, 2008). In the instance of this study, the nature of informed consent is a little more complex due to the ages of participants. Whilst all students and children participating in this study needed the approval of gate-keepers (e.g. their parents/guardians or teachers), particular attention was needed in ensuring the informed consent of the very youngest participants. Fine and Sanstrom (1988) advise that children, no matter how young are given meaningful explanations of the research, and a reasonable chance to refuse to take part, without any additional questioning or coercion. It is important that their rights are not diminished because of their age.

This study was conducted in an ethical manner appropriate to the research questions and the participants involved. Gaining informed consent from children and young people has two stages, consent will need to be sought from adults responsible for their well-being, such as parents and headteachers, and then from the children themselves (Cohen, 2008). In order for my study to be ethically sound, gate keeper consent was first sought from the headteachers of participating institutions, the administration of which was discussed earlier in this chapter. Consent was then sought from the parents/guardians of participants.

Participant information sheets and consent forms were sent home with each child or young person taking part in the study. Both parents or carers and the participants themselves needed to read the information sheets and sign consent forms. Both participants and their parents had the opportunity to ask questions, and to refuse to participate or to have their data removed from the analysis without any further questioning.

According to the BERA (2011) Ethical Guidelines for Education Research it is essential that a participant's privacy and anonymity is respected. Questionnaire participants needed to give their names so that they could be approached if necessary to participate in interviews. All data collected in this study, including survey, audio and video data, was stored securely, and backed up. All interview data was anonymised in discussion of the results in order to protect the identities of participants (for example by giving each interview participant a pseudonym). Steps were taken to ensure that participants are not in any way distressed by taking part in the study, the methods of achieving this were discussed earlier in the chapter.

Informed consent, or assent in the cases of participants under the age of 18, is not the only ethical issue to be considered in relation to this study. The BERA (2011) Ethical Guideline also contend that there are several laws that need to be observed in the collection, storage and analysis of the data. In order for the study to be considered ethical, laws regarding working with children and young adults need to be observed. In order to protect the researcher and the participants, links to the questionnaires were sent to school email accounts monitored by the institutions, ensuring that safe-guarding policies are observed. Interviews took place in areas where I was never completely alone with students. In addition to these laws, the BERA (2011) ethical guidelines also assert that research should comply with laws in relation to the storage and use of data. Participants should know where data is stored, what it is used for and to whom it is available. These issues were addressed in the participant information sheet which will be made available to all participants before they take part in the study. Data should also be held securely. In order to meet this requirement, the data collected was stored on computer that is either in my possession, or stored in a securely locked area. The data was backed up on external hard drive which was also stored securely.

4.13 Specifics of data collection and analysis in each of the research sites

Details pertaining to the specific mechanics of how data was collected at the research sites and then analysed is presented in the sections which follow.

4.14 Where was data collected?

The sections below provide the context for the data collection in terms of the makeup of the schools which participated as data collection sites. Further contextual information is also included; for example when during the academic year interviews and questionnaires were completed.

4.14.2 Key Stage One

Key Stage One data was gathered at School One, an Infants school in a semi-rural part of Hampshire. The school is fairly large, with around 450 students in Years R, One and Two.

All of the interviews discussed here were conducted during a three week period in July 2017. The participants had all completed Key Stage 1 SATs examinations in English grammar, punctuation and spelling and mathematics. They had been revising for their exams, and had been completing repetitions of potential exam questions. In the following September they were to move to a separate junior school, which while on the same larger site was a discrete building with new teachers. Since the exams were finished, they were engaging more than they had been in 'fun activities' like practising for their leavers' assembly.

4.14.3 Key Stage Two

Data was collected from Key Stage Two students at School Two. School Two is a Church of England Primary school in a suburb of Southampton. As a Church of England school, students come from outside the immediate catchment area in order to attend. The school has a two form entry in each year group, meaning that there can be up to thirty children in each year, but they are divided into two classes. To that end, there are two classes in Years Four and Six respectively. There are 467 students on roll aged between four in Year R, and eleven in Year 6.

4.14.4 Key Stages Three and Four

School Three is a medium to large sized secondary school in a rural area of Hampshire. It is an 11-16 comprehensive institution. There are 1200 students on roll. Students at the school complete Key Stage Three (KS3) studies with their first two years (Years 7 and 8), and then complete Key Stage Four (KS4) (Years 9, 10 and 11) in their final three years. Most students attended the same two feeder primary schools, but a number of students at the interview stage (five of seventeen participants) all commented that they came from outside of the expected catchment with some significant effort because of the school's good reputation. One student described how parents in a neighbouring village had designed a system of ridesharing to ensure that their children were able to attend. At the end of the three year KS4 students sit GCSE examinations. During their KS3 studies, students cover a broad curriculum comprising the core subjects (English, mathematics and sciences) together with humanities (history, geography and religious education), arts (art, dance, music and drama), physical education and technology; with a greater number of teaching hours per week dedicated to the core subjects. During Year 8, students choose four options from the non-core subjects to study at KS4 together with the core subjects. They then begin this program of study at the beginning of Year 9.

At both Key Stages Three and Four participants were grouped by previous attainment, the impact of which was mentioned specifically by some participants in their long answer questions. This is discussed in further detail in the 'Perceived mathematical concept' section of the chapter which follows. Students discussed in their responses to the long answer questions being regularly assessed on their mathematical performance, which had some impact upon their perceived mathematical self-concept, which is also discussed later.

At Key Stage Three all students cover the same curriculum regardless of their mathematical ability. Comparatively, at Key Stage Four attainment groupings become more important as these impact upon the curriculum covered. Some participants according to their long answer responses felt that they were revising content covered earlier in their mathematical educations.

When entered for GCSE examinations, teachers select either higher or foundation tier for students. The content of each tier is significantly different. KS4 participants in this study were the second cohort to study the new 9-1 content-rich mathematics curriculum. They were studying a spiral curriculum divided into set topics.

During the semi-structured interviews, students voluntarily bought their maths books with them, and were keen to share what they had learnt. A clear methodology for assessment was evident in all books. Students universally said that they knew how they were doing in mathematics because of their attainment in assessments, and marking and teacher feedback was evident in all books. All students had a tracker document in their books with anticipated grades, the grade which should be attained by students and the grade attained in their most recent assessment. All students in Years 9 and 11 were using whole GCSE mathematics papers as their principal means of assessment, with Year 9 students taking additional assessment at the end of each topic. Students were all universally confident as to the next steps which should be taken and for the most part spoke positively about their teachers.

4.14.5 Key Stage One analysis

Once interviews were complete, they were transcribed and tagged for analysis. As recommended by Miles et al (2014) transcripts were stored in a single master document for each participant. A conceptually clustered matrix of tags was built during reading, as Excel provides a number of useful organisation and analysis tools by its very nature, and by reading across the rows it was possible to begin to note relationships between variables.

The research question most pertinent to this part of the study is the first. I am seeking to understand the attitudes towards learning mathematics of these younger participants. Because of the age of the participants in the Key Stage One sample, the final two research questions are arguably less relevant, although the data presented here answer this question to an extent. In order to answer this particular research question, the approach taken to analysis of this data is generally qualitative in order to describe the attitudes and feelings of such young participants. Additionally, since the sample in this part of the study is relatively small, an entirely quantitative approach would be less appropriate. Rather the analysis in this part of the thesis seeks to describe and explain the views of younger participants, and to build some theory as to how their attitudes are beginning to develop. As such the results might not be generalizable across the school, or even the cohort as a whole. This is not necessarily undesirable. (Miles et al 2014) argue that when gathering qualitative data, too many cases become unwieldy owing to the high complexity of interview data. They suggest instead collecting richly researched cases, but not asserting any generalizability.

No qualitative study conforms exactly to a standard methodology; each calls for the researcher to bend the methodology to the uniqueness of the setting or the case (Miles et al, 2014). In the case presented here, qualitative data were gathered from young children with the intention of comparison with not only qualitative data gathered from secondary and junior school students, but also with quantitative data gathered from the secondary and junior participants. For this reason, some limited quantitative approach was necessary. Where a quantitative approach was taken for the analysis of particular interview questions, conversion of tags to numerical values was necessary for analysis, and the incidence of tags were quantified in some instances. Where these approaches were taken is explained later in the chapter with the discussion of the related data. By using this kind of limited quantitative approach, it was possible to describe some general trends.

Tags were applied to the data following the transcription of the video interviews. In order to make cross-theme analysis possible, unique tags were used for each response within each component of affect. Initially, codes generated based upon the components of attitude identified in the theoretical framework were used. As coding of the transcript data continued through the second and third readings of the data, it became necessary to code inductively, adding new codes as participants replied with unexpected responses. In these instances, an in vivo approach was taken. This inductive approach was used to find recurrent themes across the data. Finally, these were grouped into smaller constructs using pattern coding where participants had given similar responses. The resultant codebook can be seen in Appendix Four.

4.14.6 Key Stage Two data collection and analysis

Participant information sheets, letters to parents and permission forms were all sent to the head teacher. Class teachers then discussed the stages of the data collection (survey then interviews) with their classes. The paper work was distributed to students who then took them home. Fifty four students returned their completed parental permission letters. Once the letters had been returned to the class teacher, then the students were given time in school to log in to the online questionnaire link provided. All 54 students completed the online questionnaire between the 23rd November 2016 and the 26th November 2016. Of these, 23 were in Year 4, and 31 were in Year 6. The participants in Year 4 were aged between 8 and 9 years, whilst the Year 6 participants were between 10 and 11 years old. Students in both year groups answered the same set of demographic questions, 32 Likert style questions, followed by two long answer questions. As can be seen in Table 3, participants in Year 4 took on average around 15 minutes to complete the survey, with students in Year 6 taking around 11 minutes.

Table 3 – Average time taken for Key Stage Two participants to complete online surveys

	Average time taken to complete survey
Year 4	15.04347826
Year 6	10.83870968

Students initially answered some demographic questions including their names (for identifying those students who will take part in interviews in the latter part of the school year), their age in years and months, their school year and whether or not they wished to continue to study mathematics when they no longer had to. The numbers of boys and girls who participated in the online questionnaire can be seen in Table 4 below.

Table 4 – Breakdown of gender of participants by Year Group

	Year 4	Year 6
Male	8	15
Female	15	16

Whilst the numbers of male and female participants in Year 6 are fairly even, only a third of the participants in Year 4 are male. This is perhaps a limitation to consider, given the well documented history of research into male and female attitudes towards mathematics (The Royal Society, 2008).

4.14.7 Key Stage Two- Semi Structured Interviews

Once the online questionnaire data had been analysed, a sample of participants were chosen to be interviewed. Since the interviews were intended to provide some illustration and further insights into the questionnaire responses provided, rather than any quantitative data the sample size was less important. Rather the sample was chosen in order to understand the views of boys and girls in both year groups, as well as of those who did or did not wish to keep studying maths when they were no longer required to. Since the majority of students wished to continue studying mathematics 3 students of each gender from each year group were selected who indicated in the initial online survey that they would continue to study mathematics when they were no longer required to do so. A relatively smaller number of students stated in the online questionnaire that they would not continue to study mathematics, so fewer of these students were selected. The breakdown of year group, gender and preference for studying, or not studying post compulsory mathematics can be seen in the Table 5 below.

Table 5 – Breakdown of participants by gender and year group of the desire to study post-compulsory mathematics

	Year 4 (10 total)		Year 6 (10 total)	
Male	Yes	3	Yes	3
	No	2	No	2
Female	Yes	3	Yes	3
	No	2	No	2

This meant that twenty permission forms and information sheets were handed to participants by their class teachers. These were then returned to me via the teachers on the day that the interviews were conducted. Interviews were then conducted with those who returned their permission forms. The breakdown of participant demographic information can be seen in the Tables 6 and 7 below.

Table 6 – Breakdown of interview participants by Year 4 participants by desire to study mathematics and gender

	Year 4 (6 total)	
Male	**Yes**	2
	No	1
Female	**Yes**	2
	No	0
	Declined to participate on day of interview	1

Table 7 – Breakdown of Year 6 students by gender and desire to study mathematics

	Year 6 (6 total)	
Male	**Yes**	1
	No	0
	Don't know	1
Female	**Yes**	4
	No	0

Whilst there was some attrition from the original sample requested, there was still sufficient data to provide some illustrative examples and a richer analysis of the questionnaire data gathered previously. On the interview day, twelve permission forms were returned; six from years 4 and 6 respectively. There were fewer permission forms returned by those children who had stated during the online questionnaires that they would not continue to study mathematics when they no longer had to; indeed only one such participant returned his permission form. One Year 4 girl declined to participate on the day of the interviews. During this part of the data collection, eleven interviews took place in the school library. The library was chosen by the senior leadership of the school as a place with which students were used to participating in discussions, and would not perceive that they were 'in trouble' as may have been the case had the interviews been recorded as originally suggested in the office of the deputy head teacher. All of the interviews followed the same semi-structured schedule and lasted on average around 9.5 minutes. Some students bought their books with them from their lessons though not requested specifically to do so, and used examples from their books to illustrate some of the specific mathematical concepts which they were trying to explain. The interviews took place in July. Year 6 students had taken SATs exams around a month previously, and had been handed their results the day prior to the interviews. All the Year 6 participants mentioned their SATs results, indeed one student discussed that even though she had received the results, she had been too nervous to look at them. They had also received school reports which gave some context to the exam results received (e.g. relative progress from starting points, and some teacher assessment). They had made decisions about where they would attend Secondary school, and some had attended orientation days.

4.14.8 Key Stages Three and Four

Participant information sheets were provided to the Head of ICT at the school and distributed to students during their ICT lessons (which at Key Stage Four included students who had opted for ICT, Computer Science and Business Studies). Their ICT teachers discussed the study with them during ICT lessons, and information sheets and permission forms were distributed to 250 Year 7 students, 150 Year 9 students and 100 Year 11 students. In total, 95 participants completed the online questionnaire, the breakdown by year group of which can be seen in Table 8 below.

Table 8– Breakdown of numbers of Key Stage Four questionnaire participants by year group

	Total Participants
Year 7	44
Year 9	29
Year 11	22

Once permission forms had been returned to their ICT teachers, students completed online questionnaires during their ICT lessons, which took around ten minutes per student. Time spent on questionnaires varied across year groups, the specific details of which are shown in Table 9. The numbers of students who participated in Years 9 and 11 were lower than those who participated in Year 7. The procedure for increasing this sample size can be seen in the methodology chapter, and the impact of this is discussed in the Limitations section of the Discussion Chapter.

Table 9 – Average time taken to complete online questionnaire by Key Stage Four participants breakdown by year group

	Mean time taken to complete questionnaire
Year 7	15.29642857
Year 9	9.072413793
Year 11	8.717272727

Year 7 participants took the longest time on average to complete the questionnaire at around 15 minutes per student, with students in Year 11 taking around half that time. The impact on a 60 minute lesson therefor could be considered to be fairly minimal, and did not impact upon the learning of the students involved.

Using the demographic information provided by participants in the initial questions, it was possible to analyse the numbers of male and female participants by year group, the results of which can be seen in Table 10.

Table 10– Breakdown of male and female Key Stage Three and Four questionnaire participants by year group

	Year 7	Year 9	Year 11
Male	24	23	3
Female	20	6	19

Whilst numbers of male and female participants are broadly balanced amongst those from Year 7 who completed the questionnaire, the same cannot be said of those participating from years 9 and 11. In order to address this imbalance, reminder emails were sent to the school who in turn reminded students in their lessons, and added reminders to the school bulletin which was read to students during tutor times. Since participants were to an extent self-selecting as they were not compelled to complete the questionnaire, it was not possible after these measures to gather more participants in an attempt to balance genders within the sample.

4.14.9 Selection of participants for interview

Once an initial analysis of the interview data was complete, further samples of twenty-two participants were selected to take part in semi-structured interviews. A sample was chosen comprising participants from each gender representative of both those who said that they would study mathematics in post-compulsory education and those who said that they would not, as well as participants whose long answer survey questions gave a detailed or unexpected insight into reasons for choosing or not choosing post-compulsory mathematics from each of the participating year groups. Permission forms and information sheets were once more provided to the Head of IT, and were then distributed as needed.

4.15 Analysis

In the following section, the analysis of the data gathered from participants is discussed. The means by which data gathered from Likert style questions was analysed is explored, followed by the details of how data from the long answer questions which concluded each online questionnaire were tagged and prepared for analysis. An exploration of how interview data was tagged using similar methods follows, and the section concludes with how the data from each key stage was analysed in order to answer the third research question.

4.15.1 Analysis of responses to Likert-Style questions

Participants in Key Stages Two, Three and Four were provided with a five point scale with which to answer the Likert-Style questions. At one end of the scale 'Strongly Agree' was assigned a Likert value of 5, whilst at the other end of the scale 'Strongly Disagree' was assigned a value of 1. The midpoint of the scale was a value of 3, which corresponded to 'Not sure'. In order for the questionnaire data to be analysed in SPSS, the textual labels were converted to numerical labels as described.

In order to perform bivariate analysis of whether or not participants intend to study mathematics when they no longer have to with the components of attitude identified in the theoretical framework, data in the variable 'I will probably study mathematics when I no longer have to' the possible 'yes' and 'no' responses have been converted to 1 for yes, and 0 for no. There are further explanations of specific approaches to analysis taken in order to answer each of the specific in the discrete sections which follow.

4.15.2 Analysis of long answer questions

As discussed earlier in the Methodology, the online questionnaire concluded with three long answer questions. These were: 'How important is mathematics to you personally, and why?', In order to analyse the long answer responses at the end of the online questionnaire, responses were tagged and a conceptually clustered matrix built as per the analysis of the Key Stage Two long answer questions. Responses were tagged using pre-chosen codes defined by the areas of attitude identified in the theoretical framework where possible, and tagged to provide analysis of those answers which couldn't have been anticipated. Similar tags were then grouped for the final analysis. Where this has been necessary, further explanation is provided. Long answer responses have been used in to provide illustration of points from the Likert data, and in some instances as frequencies to support or expand upon points from elsewhere in the questionnaire.

4.15.3 How questionnaire items were matched to the components of the theoretical framework, and how this impacted upon analysis

Both Likert-style and long answer questions in the online surveys were designed to align with each of the components of the theoretical framework, enabling the researcher to gather data on the emotional response towards mathematics of participants, their perceived exchange values of mathematics, their vision of mathematics and their mathematical self-concepts and their normative influences. The methodology for anchoring questions to the theoretical framework is outlined below. The same methodology was used to anchor interview questions to the theory.

Questions to gather data about the exchange value of mathematics were designed to capture how students felt that they could use mathematics both now and in the future, therefore they contained words that indicated that a participant could see a usage for mathematics or not e.g. 'useful' or 'career'. Examples of these questions were 'Maths will be useful in my chosen career' and 'Maths is useful for my life after school, but maybe not for my chosen career'.

Likert items and questions to gather data about the affective component of attitude were designed to gather data about the emotions that participants felt when they were thinking about mathematics therefore they contained words related to participants' possible emotions, for example 'anxious' or 'enjoyment' examples of these included 'Maths makes me anxious.

Similarly, to the questions and items discussed above the questions and Likert statements which were designed to gather data about participants' mathematical self-concepts included words and phrases such as 'good at maths' since they were designed to enable participants to make an assessment as to how they felt about their own mathematical ability. Examples of these included 'I am good at maths' and 'I will get a grade which is higher than my target grade'.

Questions and items that were designed to capture data regarding the normative influences on participants at each Key Stage made references to specific people who could potentially exert a normative influence on children and young people, therefore they contained words such as 'friends', 'parents' and teachers as these are the people with which participants were likely to have contact e.g. 'if my friends were doing maths at college then I would to'. For this reason questions such as 'I only do maths because I have to' were considered to be part of the affective dimension, since no specific normative influence was identified. If desired however this question could be used to identify whether students only participate in mathematics because of unspecified normative influences upon them.

Questions and Likert items used for the measurement of participants' general visions of mathematics were those which contained adjectives such as 'boring', 'fun' or 'interesting' e.g. 'Mathematics is fun'.

Because the questions were aligned with each of the components of the theoretical framework, analysis of the differences in 'attitude' towards mathematics of participants at each key stage was possible. Using the divisions of questions outlined above, it was then possible to choose questions to make comparisons about the relative impact of the components of attitude of decision making, as well as understanding the attitude towards mathematics of participants in each of the key stages, for example when comparing the vision of mathematics of those participants who wished to study post-compulsory mathematics with those who didn't, it was possible to correlate 'I will study mathematics when I no longer have to' with 'Mathematics is fun' and 'Mathematics is boring'.

4.15.4 Analysis of data to make comparisons across Key Stages

In order to make comparisons across Likert items, data sets from Key Stages Two, Three and Four gathered from the online questionnaires were merged in Excel, and then imported into SPSS for further analysis. This made it possible to draw Pearson correlations from across the data sets. In some instances, median averages have been used to make comparisons across year groups. Whilst there were some differences in the semantics of how questions were posed in order to provide some support for the different reading ages of children in the study, the meaning of the questions chosen for comparison of Likert items in this part of the thesis are essentially the same, for example 'I don't think that I will need maths for my job when I grow up' in the case of the questionnaire completed by participants in Key Stage Two and ‘With the career path that I have in mind I don’t need mathematics’ for participants in Key Stages Three and Four.

Where each of these methods of analysis have been used are discussed in the relevant sections below. Because of the relatively young physical and reading ages of the Key Stage One participants online questionnaires were not possible and data was gathered using solely semi-structured interview. For some components of attitude towards mathematics quantitative analysis was possible, for example in the instance of normative influences. For these components, quantitative analysis and the resultant discussion is included in this chapter. For components of attitude where this was not possible, qualitative discussion is included for Key Stage One participants and compared with data and discussion from those participants in Key Stages Two, Three and Four.

4.16 Changes undertaken as a result of the pilot study

The pilot study was conducted in my own school, and as a result I knew nearly all of the participants personally, as well as all of their mathematics teachers. As a result, I faced an ethical dilemma. There is an inherent hierarchy between teachers and students (Greene and Hogan, 2005) and as such teachers exert an authority over the children and young people that they teach. For this reason, participants may have felt obliged to participate in the study even though they did not have to in order to ‘make me happy with them’. This is magnified by my senior position within the department and within the school as a whole. I also faced the ethical dilemma that I might have heard disparaging comments about my colleagues which as a senior member of staff I would perhaps be obliged to act upon. Because of this dichotomy, I decided to conduct my secondary research in another comparably sized school within the locality.

As part of the pilot study, in order to make an informed comparison between the efficacies of collecting qualitative data by focus group in comparison with individual interviews, one small focus group was conducted towards the end of the pilot study. Six participants from Year 7 were involved, two students who enjoyed mathematics, two students who identified that they did not like mathematics, and two students who identified that they neither liked nor disliked mathematics. As with the individual interviews, the focus group interview was audio recorded. Gathering data in this way made it possible to gather data more quickly from the larger number of participants, and allowed for some comparison of attitudes within the same interview, which is more difficult when analyzing data from individual interviews. However, participants were fairly reluctant to talk in front of each other, even though they were from the same tutor group and used to doing group work together. It was also difficult to identify which child was responding to questions. Since the aim of this focus group was to explore why individual had answered in the way they demonstrated on their questionnaires, the focus group was a less effective way of achieving this aim than the individual interviews. The data gathered had less depth, and therefore less quality in exploring why students felt as they did about learning mathematics. For this reason focus groups were not used in this thesis. Instead all qualitative data was gathered using semi-structured interviews as described in the methodology which follows.

Whilst the methods of data collection used in the pilot study provided a means to answer all of the research questions effectively, there were some changes that needed to be made before implementation of the main study.. It is also unclear from the data gathered in the pilot study what makes teachers a normative influence that students consider when making decisions about future directions for study; for example is this because they like their teacher? Or is it because they believe their teacher to be effective? Further questions were added to the semi-structured interview schedule in order to address this gap.

Since this pilot study was completed, there has been some significant change in governmental policy (Department for Education, 2014) which requires students to continue compulsory education until the age of 18. There has also been some suggestion that students should be required to study mathematics in some form until the time that they leave compulsory education (Hodgen et al, 2013). There have been significant changes to the structure of post-16 qualifications, for example AS-Level mathematics is no longer awarded at the end of the first year in such a way that it will count towards the terminal qualification; rather all of the external examination occurs at the end of the second year. In order to future proof this thesis adjustments were made to the questions posed.

In the chapter which follows, the resultant data collection is analysed.

Chapter Five - Findings

5.1 Introduction

In this chapter, the findings from the overall study are presented. This study aimed to resolve three major research questions; these were

1. Do the attitudes of school students towards mathematics differ at different ages, and if so, how?

2a. 'What are the factors which affect a student's attitude towards choosing to study Mathematics in post-compulsory education?'

2b. 'Which of these are the most dominant?'

Conclusions are drawn about research questions 1, 2a and 2b from the three different research sites. Research question one is addressed first in the dimensions of attitude towards mathematics addressed in the theoretical framework.

5.2 Curriculum Changes

At the time data was collected for this thesis, the curriculum across all subjects was undergoing major changes across all Key Stages. Scales used to grade assessments were changed, and the content taught at all Key Stages became larger. As a result, students at every Key Stage (with the exception of Key Stage One) were learning newer, larger content for which they had not completed the new content from the previous Key Stage. Whilst this is not particularly evident in the findings, it is an important part of the context of the study which should be considered.

5.3 What were students learning at each Key Stage?

In order to provide some context, in the following section the content learnt by students in each Key Stage is discussed. This can be seen in Appendix Eight.

5.4 Do the attitudes of school students towards mathematics differ at different ages, and if so, how?

In this section, the first research question is addressed. Since one of the main problems proposed in the literature review is the smaller than desirable numbers of students opting for post-compulsory mathematics courses, the first area to be addressed is whether or not participants wished to study post-compulsory mathematics. This desire has been compared across all year groups in all Key Stages.

In some instances non-significant correlations have been discussed following analysis whilst some other non-significant correlations have not. Combined use of qualitative and quantitative findings were used to decide which of these were worthy of further discussion. In instances where a number of interview participants had discussed a component of attitude, or individuals had provided explanation of why this particular component was influential to them personally, further discussion was made e.g. whilst there was not a particularly strong correlation between a participants' perceptions of utility of mathematics for their chosen careers and wanting to study post-compulsory mathematics from analysis of the Likert items, when interviewed participants were all able to discuss why mathematics might be useful to them one day.

5.4.1 Did participants express a desire to study post-compulsory mathematics?

In this section, the most relevant part of the combined theoretical framework comes from Azjen' (1991)Theory of Planned Behaviour. According to the theory, the attitudinal factors of whether a person thinks that they might be successful in emitting a behaviour, and whether the behaviour is of value to them impact upon the ultimate intention to emit the behaviour. In the instance of this thesis, the behaviour in question is the intention to study post-compulsory mathematics. For this reason, it is necessary to consider whether participants intend to study mathematics at all when they no longer have to. This is considered in depth in the section which follows.

In order to understand how the desire to study post-compulsory mathematics changes over the course of the infant, primary and secondary educations of students all of the 'yes' and 'no' answers gathered in the three research sites have been converted to '1' and '0' respectively. Data from the online questionnaire was used to make this comparison in the instance of participants from Key Stages Two, Three and Four. This was a little more complex in the instance of data gathered from Year 2 infant school participants. Because they took part in interviews only, they had some latitude in the responses that they gave. Three of the twenty two participants responded 'maybe' and one responded 'I don't know'. For the purposes of comparison, these answers were given a value of .5, since participants were undecided.

Table 11 – Likelihood of participation in post-compulsory mathematics by Year Group

Year Group	Likely to study post-compulsory mathematics
Year 1	0.77
Year 4	0.68
Year 6	0.74
Year 7	0.61
Year 9	0.57
Year 11	0.09

Whilst the interest of studying post-compulsory mathematics appears to pique somewhat in those participants in Year 6, the general trend across the entire cohort was that students become less inclined to study mathematics when they no longer have to as they get older. The most significant and noticeable decrease in interest occurs between Years 9 and 11.

The potential reasons for this decrease in interest are discussed using the lens of the components of attitude in the sections which now follow, but it is first necessary to consider the overall enjoyment of school in general, and how this changes over time.

5.4.2 Enjoyment of school at Key Stage Two

The mean Likert scores given in response to the statements 'I enjoy maths' and 'overall I enjoy school' by participants in Key Stage Two can be seen in Table 12 below.

Table 12 – Mean Likert score in response the question 'I enjoy mathematics' by Key Stage Two participants

Report

	I enjoy maths	Overall, I enjoy school
Mean	3.94	4.11
N	53	54
Std. Deviation	1.307	1.022

In general, participants in both years reported that they enjoy school. The mean Likert response here was slightly above four meaning that the majority of students responded that that they either agreed or strongly agreed that they enjoyed school. By comparison, students reported that they enjoyed mathematics a little less. The mean of Likert scores given in response the statement 'I enjoy maths' was 3.94. This is broken down further into frequencies in the Table 13 below.

Table 13 - Frequencies of Key Stage Two participants agreeing with each Likert score in response to the item 'I enjoy maths'

I enjoy maths					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	4	6.9	7.5	7.5
	2	6	10.3	11.3	18.9
	3	4	6.9	7.5	26.4
	4	14	24.1	26.4	52.8
	5	25	43.1	47.2	100.0
	Total	53	91.4	100.0	
Missing	System	5	8.6		
Total		58	100.0		

The majority of participants answered either that they either agreed or strongly agreed that they enjoyed mathematics. Indeed, 43% reported that they strongly agreed that they enjoyed mathematics. This poses some problems with the analyses of later statements, and the statistical validity of the findings since the number responding that they either disagreed or strongly disagreed that they enjoyed maths was fairly small. This potentially makes any definitive findings about why participants may not enjoy mathematics less secure, or why they may not wish to pursue post-compulsory mathematics less secure.

5.4.3 Enjoyment of school at Key Stages Three and Four

By comparison, students at Key Stages Three and Four reported a declining enjoyment in both mathematics and in school in general. Whilst the enjoyment of Year 7 students is comparable to those students in Year 6, a decline is evident in both Years 9 and 11.

Table 14– Participants' general enjoyment of school by year group at Key Stage Four

	Overall I enjoy school (Median Likert value)
Year 7	4
Year 9	3
Year 11	3

Participants appear to have arrived at School X with a relatively positive disposition towards school, with the median Likert score from Year 7 students of a 4, indicating that students agreed that that they enjoyed school. However in both Years 9 and 11, students were more inclined to give a Likert response of a 3, indicating that they were more inclined to respond that they didn't know whether they liked school in general. Whilst there is a general decline in enjoyment in school, this is not reflective of the apparently sharp decline in the desire to study post-compulsory mathematics. This is not due to enjoyment of mathematics as a sole factor, as can be seen in Table 15 below, the decline in enjoyment in school is steeper than that of enjoyment of mathematics.

Table 15- Comparison of correlations between school year and enjoyment of overall school and enjoyment of mathematics

		School Year	I enjoy maths	Overall, I enjoy school
School Year	Pearson Correlation	1	-.129	-.236*
	Sig. (2-tailed)		.214	.022

Whilst there is a moderate negative correlation between overall enjoyment in school and school year, participants enjoyment of mathematics is not significantly different to how much students in secondary education enjoy school in general. Indeed when the means of the Likert items concerning enjoyment in school, and enjoyment of mathematics are compared, there is very little diference as can be seen in Table 16 below.

Table 16 – *Comparison of enjoyment in mathematics and overall enjoyment in school of Key Stage Four participants*

	I enjoy maths	Overall, I enjoy school
Mean	3.26	3.28
N	94	94
Std. Deviation	.994	1.177

The reasons for this decline are examined in the analysis of Likert items and long answer questions in the sections which follow. Further consideration in the decline in enjoyment of school over time can be seen in the Discussion chapter.

5.5 Analysis and discussion of the attitudes of participants towards Mathematics at each Key Stage in the dimensions of attitude defined in the theoretical framework

In this section, the attitudes towards mathematics across each of the Key Stages are discussed in each of the dimensions identified in the theoretical framework. The second of the three research questions 'What are the factors which affect a student's attitude towards choosing to study Mathematics in post-compulsory education?**'** is addressed.

5.5.1 Vision of mathematics

For the purposes of analysis and clarity of description, the two component parts of 'Vision of mathematics' have been split into 'The perceived exchange value of mathematics' and general vision of mathematics (e.g. 'Maths is fun' or 'Maths is boring').

5.5.2 Perceived exchange value of mathematics

In this section, the perceived exchange value of mathematics is broken down further into two separate constructs. These are: The utility of mathematics for participants' chosen careers, and their perceived exchange value of mathematics outside of school. Additionally, they were asked to consider their own uses of mathematics outside of school, as well as how they thought that their parents might use mathematics.

Across all Year groups and key stages, participants in general agreed that mathematics was 'important'.

Table 17 – Perceived exchange value for chosen career by Year Group for all questionnaire participants

	I know what I want to do for my career	With the career path I have in mind I don't need mathematics	Maths will be useful in my chosen career
Year 4	4	2	4
Year 6	4	3	4
Year 7	4	3	3
Year 9	4	2	3.5
Year 11	4	3	3

The reasons why, and discussion with participants is included by Key Stage in the sections below

5.5.3 The exchange value of mathematics as perceived by participants in Key Stage One

Participants were then asked to consider their chosen careers. As an opening question to this section, all participants were asked if they knew what they wanted to be when they grew up. Once it was ascertained that a participant knew what they wanted to be, there was a discussion of the type of career that they might like to have. They were then asked whether mathematics might be important in their chosen career. Those participants who did not know what they wanted to be were asked to consider whether mathematics would be important in any job that they chose later on.

The majority of participants had some ideas about what they would like to be when they grew up; of the twenty two participants interviewed, seventeen knew what kind of a job they would like one day. In general, the jobs identified by participants were largely limited to those of which children have some experience, for example being a teacher, doctor, vet or sports person (e.g. footballer or cricketer) were all popular options. Of the twenty two participants interviewed only five did not have an idea of the career that they wanted. All of the remaining participants had some ideas of how mathematics might be useful in their chosen careers. Amongst the responses, ten participants successfully suggested how mathematics would be useful in their chosen careers.

There was not necessarily a link between a participant's desire to continue to study mathematics, or the belief of the participant that they were 'good' at mathematics.

Int: When you don't have to study maths any more are you going to study it or not study it?

James A: I might study it a little

Int: Why won't you study it a lot?

James A: Because it's just not my kind of thing.

Int: Why is it not your kind of thing?

James A: I find maths actually rather tricky.

Int: What's tricky about it?

James A: Like timesing and dividing

Int: What about fractions? You know when you like colour in the half?

James A: I like the colouring bit.

Int: You like the colouring bit, but not the other bit.

James A: No.

Int: What about your alien words. Do you like doing alien words?

James A: Yeah I do.

Int: So what's the best out of alien words and maths?

James A: I think aliens are best

Int: You think aliens are best. Why are they the best?

James A: Because I like to test myself at how good I am at things that I might really have to use one day.

JamesA-Y2-Interview

In the excerpt shown here from James A's interview, James demonstrably does not wish to study mathematics. He believes mathematics to be 'tricky' and 'not his thing'. He is able to identify mathematical operations with which he is struggling (multiplying and dividing), and identifies his preference for 'alien words' (synthetic phonics) over maths. However, later in the interview, James A identifies that he would like to be a policeman.

Int: That's interesting. So do you think that you'll really have to use maths one day?

James A: I might. Because when I grow up I'm thinking to be a policeman

Int: Why? That would be excellent. I'd like to be a policeman.

James A: Because like if there was 10 vans…no 2 vans and 10 people I need to know how much can fit in each.

Int: Perfect

James A: There's five in each

James A-Y2-Interview

In this example, James is able not only to give a concrete, relevant example of how mathematics might be useful to a policeman; he is able to demonstrate a sensible, unprompted idea of how his idea might work functionally. Participants variously equated the need to measure blood pressure with being a doctor, understood that a dance teacher might need to count steps, identified that a hairdresser would need to tell the time to keep appointments and work out the change that clients needed, and that teachers would need to be able to count, use rulers and be able to help children.

Some participants chose careers which were more mathematical in nature. There was some variance in the understanding of the practical applications of mathematics that would be required.

Milo: I think I'm going to go into space.

Int: You're going to go into space. Magnificent. What are you going to do in space?

Milo: Go to the moon!

Int: When you're an astronaut, going to space, is maths going to be important or not important

Milo: No

Int: No it's not going to be important? Why don't astronauts need maths?

Milo: Because all they're doing is having a visit on the moon and they're not really doing anything. All they're doing is jumping up and down and exploring.

Milo-Y2-Interview

Whilst Milo has an idea, that he would like to be an astronaut, he has not yet developed the understanding of why mathematics would be essential for his chosen career. Earlier in his interview, Milo identified that he probably would study mathematics if he no longer had to, but when asked why he might continue his mathematical studies, replied:

"Because I think it's important and if you don't do maths then you won't really learn very much"

Sam also wished to continue to study mathematics and had an idea of his preferred career.

Int: One day, when you don't have to study maths anymore, are you going to study it or not study it?

Sam: It depends what job I want to choose.

Int: Interesting. So tell me a bit about what jobs you want to choose.

Sam: Driving an airplane.

Int: Excellent!

Sam: Because you need to know maths to know how far up in the sky you need to be. And how far away from the plane you need to be.

Int: That is brilliant! How do you know that? Did you just think of it yourself?

Sam: My mum works for NATS and it's an airplane company.

Sam-Y2-Interview

In contrast to Milo, Sam had some realistic ideas as to how mathematics could be used in his chosen career of ‘pilot’. This is potentially due, at least in part, to the normative influence of his mother who works for NATS.

Participants were perhaps influenced in their thoughts about careers by the adults with which they were familiar. Of the twenty-two participants, three wanted to be teachers, and three wanted to be doctors. All were able to suggest appropriate uses for mathematics in these careers. In the extract below, Kia expresses her wishes to become a teacher

Int: Yeah? Ok. Do you know a bit about what job you’re going to have when you grow up?

Morgan: A teacher.

Int: Do you think that teachers use maths?

Morgan: Nods

Int: Yeah? How do you think teachers use maths?

Morgan: Well, they learn maths in college and then they go and be a teacher helping maths and literacy.

Morgan-Y2-Interview

Morgan was aware that teachers would need mathematics, and she could suggest some limited but appropriate uses, for teaching numeracy. She was unable to give consideration to wider professional uses, for example calculating test scores.

Similar voluntary contributions from participants about their normative influences are discussed later on in this chapter, and will be compared elsewhere in the thesis with impact of the normative influences on older participants later in the thesis.

The second aspect of the exchange value of mathematics to participants explored in this study is the perceived importance of mathematics to outside of school. Participants were asked to think about whether mathematics was important to them outside of school, and how they used it. The overwhelming majority of participants (eighteen of twenty two) identified that maths was either important, or sometimes important to them outside of the time that they spend in school. In general, participants found it difficult to separate mathematics completed as exercises at school, and the functional utility of mathematics in the real world, describing mathematical operations that they use, but not necessarily being able to give them any kind of functional context, as illustrated in the excerpt below.

Int: You think no. Ok, do you think…do you ever use maths outside of school?

Portia: Yeah.

Int: Yeah? What do you use it for?

Portia: Just like…for adding, you take it away something, and then for adding you add more numbers to it.

Int: That is very true. Can you think of any times outside of school that you might need to do that?

Portia: No.

Portia-Y2-Interview

Whilst Portia was absolutely certain that she used mathematics when she wasn't at school, and was able to think of a mathematical operation, she was unable to think of any practical application of the example that she gave. Similarly, participants identified that they used mathematics for both 'challenges' and homework outside of school.

Int: Ok, so maybe they'll need maths for knowing the money. I think you're right they'll need to know maths for what time the people are coming. Do you ever need to know maths outside of school?

Abi: For homework, when I, homework when I do challenges on myself

Int: Yeah? What challenges do you do?

Abi: Taking away, times and adding

Int: That sounds brilliant. So you just make yourself up little challenges

Abi: When I can't think of anything to do

Int: When you can't think of anything to do. Are there any other times you use it, like when you're doing things

Abi: When my mum asks me to count money for her. Sometimes I go to her work which is Eastleigh Borough Council and do some stuff which is money

Abi-Y2-Interview

Abi's excerpt begins with a response fairly representative of those students who identified that they liked to create challenges for themselves. In instances where participants cited 'challenges' as a way that they used mathematics outside of school, they meant that like Abi they created example operations to try. In some cases, these challenges were given to them by a parent or other adult. In instances where participants were able to identify practical applications in the real world of the mathematical skills that they had learnt in school, one of the most popular uses identified was counting money, although unlike Abi, in some cases this was the only utility of mathematics outside of the school that the participant could identify.

In limited cases, participants were able to identify uses outside of mathematics for mathematics sake. Five participants identified uses for mathematics outside of challenges, homework and money. These five participants identified uses of mathematics in play and in out of school learning. Some examples of this are evident in the excerpt from the interview with Libby, shown below.

Int: Do you ever use maths not for doing homework, but for doing maths outside of school.

Libby: Yes, because sometimes I find ladybirds and I count the spots on their back.

Int: That's fantastic! Do you use it for any other things?

Libby: Sometimes I play schools at home.

Libby-Y2-Interview

Similarly to her peers, when asked whether she used mathematics outside of school, Libby responded that she used mathematics when she was doing her homework. However, when prompted, Libby identified several uses of mathematics outside unrelated to her school work, 'challenges' or her homework. Libby demonstrates here how mathematics has been useful for her in creative play, albeit using a context with which she is very familiar since she is a pupil in a school herself! Additionally, Libby also identifies that she uses maths to count the spots on a ladybird. There were a limited number of responses from other participants that also indicate the use of mathematics for exploring the natural world, for example one participant described how he would use mathematics to count the rings on a tree to see how old it was, whilst another described how she needed to know mathematics to know when her pet butterflies would emerge from their cocoons.

Three of the participants stated that they thought mathematics was useful when they played board games, as can be seen in the expert from Heather's interview below.

Int: I guess so. Because you are still doing challenges and stuff. Do you use it for any things that aren't school related?

Heather: Sometimes I do it in games.

Int: What like board games?

Heather: Like when I have to roll the dice and count up the numbers. Sometimes when I am playing ball I sometimes count how many bounces.

Int: What like the thing with the balls?

Heather: SO I bounce a ball and I try to see how many bounces I can get to the other person.

Int: Oh I see! So you count how many times you're bouncing it to each other

Heather: Yeah and I try and beat the score how many bounces. Once I got three, and then I got one and then I got none

Heather-Y2-Interview

A smaller number still said that they used mathematics when 'helping parents', giving examples of helping with working out what was needed when shopping, as well as weighing and measuring when cooking. Of the twenty-two participants, the majority were able to express ways in which mathematics was useful in their leisure time.

In the final part of this section of the interview, participants were asked to think about whether adults might use mathematics outside of work. Out of the twenty two participants surveyed, fifteen believed that adults (for example their parents) use mathematics outside of work, whilst five believed that adults had no use for mathematics in the real world. The participants had formed this belief on the basis that they had never seen their parents do maths, so it was unlikely that they did it. Again, the most commonly cited explanations for adults needing mathematics outside of work were for 'money' reasons, and in order to help children with homework. However there were instances of recognition of ways in which mathematics might be useful for adults beyond the obvious, as can be seen in the excerpt from Annie's interview below.

Int: Yeah, that bit's important as well. Do you think that adults use maths when they're not at work?

Annie: Yeah.

Int: Yeah? What do they use it for?

Annie: For like saying how many days it is until someone's birthday and for the time.

Annie-Y2-Interview

Annie had made a clear connection between dates and counting days as well as the time.

In the sections which follow, findings from later Key Stages are discussed.

5.5.4 Perceptions of how adults use maths by Key Stage One participants

When asked whether they thought that their parents used mathematics outside of work, ten of the thirteen Key Stage One interview participants responded positively. The most commonly cited reasons were comparable with those from those participants in Key Stage One. Most responded with fairly typical numerical operations such as paying bills, working out how much to pay for petrol as well as shopping and cooking.

Some participants had trouble separating what their parents did at work from how they might use mathematics in their day to day lives, although this could perhaps be attributed to children being used to seeing their parents working from home.

Emilie: Um, well they use it when they're my dad uses it a lot because he has his own business

Int: Yeah? What does he do?

Emilie: When he's paying the staff he has to try and work out how much they need and add it all together

Int: Ok

Emilie: And my mum she probably uses it sometimes she makes cakes for people and she's finding out how much they're needing to pay as well

Emilie-Y2-Interview

In the example above, Emilie had two self-employed parents who had both evidently used mathematics in her presence.

5.5.5 The exchange value of mathematics as perceived by participants in Key Stage Two

Participants in Key Stage Two were also asked to consider how valuable mathematics is to them at this point in their lives, and how valuable it might potentially be when they leave school. At this point in the thesis, it is useful to consider the extent to which participants have made decisions about their future careers. This can be seen in Table 18 below.

Table 18 – *Frequencies of Key Stage Two participants choosing each Likert score in response to the item 'I know what job I want one day'*

The extent to which participants agreed with the statement "I know what job I want one day"	Numbers of participants who selected each statement
Strongly Agree	19
Agree	16
Not sure	13
Disagree	3
Strongly Disagree	2

Of the entire sample of fifty four participants across the two year groups, the majority had some idea of what their chosen career might be.

Table 19 – *Frequencies of Key Stage Two participants choosing each Likert score in response to the item 'Maths will be useful for my chosen job'*

The extent to which participants agreed with the statement "Maths will be useful for my chosen job"	Numbers of participants who selected each statement
Strongly Agree	21
Agree	13
Not sure	16
Disagree	2
Strongly Disagree	2

When looking again at the entire sample across the two year groups, the majority either agreed or strongly agreed that mathematics would be useful for their chosen careers. The numbers can be seen in Table 19.

The majority of participants in Key Stage Two believed that mathematics would be useful for their chosen careers. Whilst there was no particular item that gathered data about what those chosen careers might be, participants made specific, unprompted references to this in their responses to the long answer items which concluded the questionnaire. This is discussed more expansively later in the chapter.

In order to understand how participants' perceptions of the exchange value of mathematics changed according to the ages of the participants, the responses to all those statements related to the exchange value of mathematics were correlated with their school year.

Table 20 – Correlation with school year and the perception that mathematic was useful (Key Stage Two participants)

		Which school year are you in? -- --	Maths will be useful for my life after school, but maybe not for my job	I can think of lots of ways that maths is useful outside school	Maths will be useful for my job when I leave school	I don't think that I will need maths for my job when I grow up
Which school year are you in? -- --	Pearson Correlation	1	.125	.222	.100	.099
	Sig. (2-tailed)		.373	.106	.472	.486
	N	54	53	54	54	52

Again, it is important to note that the correlations that it was possible to draw in this section are not particularly statistically significant, with the strongest correlation (that between school year and being able to think of lots of ways that maths is useful outside of school) is only .222. Although as can be seen in the section above, perhaps there is some emerging evidence that students perceptions of mathematics might be becoming more 'negative', by contrast there is some potential evidence in this part of the data set that as students progress through Key Stage Two their ideas of the utility of mathematics begin to crystalise. There was some correlation between students becoming older, and identifying real world application of mathematics with correlations of .125 between school year and believing that maths might be useful after school, and .222 between school year and being able to think of lots of ways that mathematics was useful outside school.

In Table 21 shown below, the mean of the Likert scores given in response to the statement 'I know what I want to be when I grow up is shown.

Table 21 - *Mean of the Likert scores given in response to the statement 'I know what I want to be when I grow up' Key Stage Two participants*

	N	Mean	Std. Deviation	Std. Error Mean
I know what I want to do for my job when I grow up	53	3.89	1.086	.149

As can be seen in Table 21, in general students had a fairly good idea what their chosen career to be, therefore it is appropriate to consider their future career aspirations as a possible vector for their perceptions of the exchange value of mathematics.

When asked to identify how important mathematics was to them and why in the long answer section of the questionnaire, the overwhelming majority (forty six of fifty five students) identified that mathematics was either 'Important' or 'Very Important'. This pattern was not necessarily indicative of an intention to study post-compulsory mathematics, however. Amongst the fourteen students who stated that they would not continue to study post-compulsory mathematics, eleven identified that it was either important or very important to them.

Table 22 – *Frequencies of Key Stage Two students who agreed that mathematics was either important or very important in long answer questions*

Important	31
Very important	15

Table 23 – *Answers from reasons why mathematics is important tagged as 'maths will be important for my chosen career' and 'maths is generally helpful'*

Maths will be important to my chosen career	17
Maths is generally helpful	15

The majority of who believed mathematics to be either important or very important cited that they felt that it would be helpful in their future working lives (either for a specific career that they had in mind, or that it might help them to 'get a good job'), or that mathematics would be 'helpful in general'. Continued support for the exchange value of mathematics is evident in the data collected during semi-structured interviews. With only two exceptions, participants agreed that mathematics would be useful for their chosen careers.

Int: Ok. So you said when we did the questionnaire on the computer you said that you would keep studying maths when you didn't have to anymore, why's that?

Rosie: Because at the time I wanted to become a planner and if someone asked you how big the house was inside, you'd have to know your maths so you would add all of the rooms up and the hallways and all that to find out how big the inside of it was.

Rosie-Y4-Interview

She was able to present some reasonable arguments about why mathematics was useful for her, and later in her interview said that she loved mathematics and would definitely study it later. It is also worth noting that her father is a town planner, and this is perhaps indicative of having a normative influence beyond simply suggesting that she should study mathematics, as discussed previously in this chapter.

Not only were those participants with a clear career path in mind able to identify the utility of mathematics at work, participants also identified that mathematics might be useful whatever your job, as was made evident by Carmen in Year 4.

Carmen: Even if you're unemployed it could help you get a job

Carmen-Y2-Interview

In Table 24 shown below, the intention to study mathematics when it is no longer compulsory is correlated with those statements pertaining to the perceived exchange value of mathematics; whether or not participants perceived that maths might be useful for their job when they leave school, whether they could think of lots of ways that mathematics is useful outside of school, whether they thought that mathematics might be useful in general after school although not necessarily for their job, and whether they thought that mathematics definitely would not be useful for their chosen careers.

Table 24 – *Correlation of the intention of Key Stage Two participants to study mathematics and their perceived exchange values of it*

		I will probably study maths at college -- --	Maths will be useful for my job when I leave school	I can think of lots of ways that maths is useful outside school	Maths will be useful for my life after school, but maybe not for my job	I don't think that I will need maths for my job when I grow up
I will probably study maths at college -- --	Pearson Correlation	1	.263	.328*	.083	-.242
	Sig. (2-tailed)		.054	.015	.554	.083
	N	54	54	54	53	52

Whilst there was some correlation between the intention to study mathematics, and some of the exchange value statements, none of the correlations were particularly significant. The strongest correlation observable in the data was that with between being able to see some practical utility in mathematics outside of school, although at .328, this is not particularly strong. This is again supported by the data from the long answer questions, in which the majority of the participants who agreed that they would continue to study maths when they no longer needed to also identified that mathematics was ‘generally useful’.

When questioned at interview as to how they used mathematics in the real world, the answers given by students didn’t change significantly between Key Stages One and Two. When asked what their parents used mathematics for, students gave similar answer to their own perceived practical uses of mathematics. Amongst the most common were shopping, cooking and paying bills. Again, Xander in Year 6 gave an answer fairly typical of others in his year group.

Int: Does your mum use maths outside of school?

Xander: Yeah.

Int: Well, she doesn't go to school, but does she use maths?

Xander: Yeah.

Int: Yeah. What does she use it for?

Xander: Counting money, counting how much food we need. Errmm....ermmm.....counting how much we need to buy at the shop

Xander-Y6-Interview

Finally, participants at each Key Stage were asked to consider whether adults used mathematics when they weren't at work. The findings from this part of the study can be seen in the excerpt which follows.

Int: And help out. Ok, interesting. Do you think adults ever use maths outside of work?

Abi: Yeah.

Int: Yeah? What do you think we do with it?

Abi: Counting money, helping their children with homework and I don't know

Abi-Y2-Interview

Abi's perceptions of how adults might use mathematics were limited to her own experiences of what she had seen them do, meaning that her understanding was that they used it for money and homework, but that it was difficult to imagine any uses beyond these.

5.5.6 Perceived exchange value of mathematics at Key Stage Four

In this section the perceived exchange value of mathematics by students in Key Stages Three and Four is considered. The first comparison made is the median Likert responses of students in Years 7, 9 and 11 of those questions related to chosen careers.

Table 25- Frequencies of Key Stage Four students by Year group compared with Likert items related to chosen careers

	I will probably go to university	I know what I want to do for my career	With the career path I have in mind I don't need mathematics	In the career I want, calculations will be worked out for me	Maths will be useful in my chosen career
Year 7	4	4	3	3	3
Year 9	4	4	2	3	3.5
Year 11	3	4	3	3	3

The overwhelming majority of students across all year groups knew what they wanted to do for their future careers. With the exception of Year 9 students, the median response was that students simply didn't know whether they would need mathematics for their careers, or whether calculations would be performed for them.

Table 26 below demonstrates the correlations between the intention to study post-compulsory mathematics and participants'' chosen paths of progression once they leave post-16 education of those participants in Key Stage Four.

Table 26– Correlation of the intention to study mathematics with Likert items related to chosen career at Key Stage Four

		Do you plan to study mathematics once you leave secondary school? -- --	With the career path I have in mind, I don't need mathematics	In the career I want, calculations will be worked out for me	I don't know what I want to do yet, but maybe maths will keep doors open to me	I hope to study maths if I go to university	Maths will be useful in my chosen career
Do you plan to study mathematics once you leave secondary school?	Pearson Correlation	1	-.175	-.221*	.239*	.653**	.489**
	Sig. (2-tailed)		.090	.032	.021	.000	.000

When considering the analysis of these items, it is important to remember that participants from all year groups in this part of the study had a fairly crystallised idea of what their future career might be, with a median Likert response across all year groups of 4 indicating that in general students agreed with the statement 'I know what I want to do for my chosen career'. Unsurprisingly, the strongest correlation with wanting to study post-compulsory mathematics here is that with hoping to study mathematics at university with a correlation of .653, This is followed by a fairly strong correlation of .489 with seeing a utility for mathematics in their chosen careers.

In the long answer items, students from across both Key Stages sampled independently made links of the value of mathematics to their chosen careers where relevant for example when asked how important mathematics was to him and why Brendan asserted that

'I think maths is important because when I grow up to get a job I will be a builder. so maths will help a lot.'

A range of future career aspirations were evident in the long answer questionnaire data including teacher, programmer and footballer. In all of these instances, participants identified precisely how mathematics would be useful, for example

'I will need to make lots of measurements if I am a builder.'

Additionally, participants identified a more general value in mathematics for example *'It's very important because its involved in most careers'.*

Brendan-Y7-Interview

By contrast, Emily in Year 11 perceived that a large proportion of the mathematics taught to her was unlikely to be useful in later life, and for her desired career as a travel journalist.

Int: Have you got a career that you've decided on?

Abi: Probably like travel journalism or travel photography something like that

Int: And do you think maths will have any impact on that at all?

Abi: Oh very. Like if you don't know it you would probably struggle. But some things you need to know to be smart but you don't actually use it.

Emily-Y11-Interview

In the excerpt above, Emily was considering whether mathematics would be useful in her dream career of being a travel journalist or photographer. Whilst she was willing to concede that mathematics might have some impact upon her working life, she thought that much of the content she had been taught she would never actually use.

However, in both the long answer responses in the questionnaires uses of mathematics outside of school were largely limited to use of mathematics for shopping. No respondents gave details of how mathematics might be useful in their leisure time.

When asked for practical uses of outside of school a narrower range of uses were suggested by Key Stage Four students than those in Key Stages One and Two. Most of these were related to money and shopping as can be seen in the extract below.

Int: Ok. How important is maths to you outside of school?

Tony: Quite important

Int: Yeah? What kinds of things do you use maths for?

Tony: I would say like going to the shops and that…like if you had an amount of change you have to add it up quick to give to the person that's serving you

Tony-Y7-Interview

The implications of this lack of practical application are discussed in relation to the literature in the discussion chapter.

5.6 General Vision of mathematics

The second factor to be considered in this section is participants' general perception of mathematics. They were asked to consider to what extent they agreed or disagreed with the following statements: 'Maths lessons are fun', 'Maths is difficult', 'I find maths boring'. This aspect of the theoretical framework is explored by Key Stage in the sections which follow.

Table 27 – Median Likert scores by Year Group of perceptions of mathematics across Key Stage Two, Three and Four participants

	Maths is boring	Maths is fun	Maths is difficult
Year 4	2	4	2
Year 6	2	4	2
Year 7	3	3	3
Year 9	3	3	2
Year 11	3.5	2	4

As participants grew older, they found mathematics to be more difficult, less fun, and became more inclined to agree that mathematics was boring. This is explored in depth in the sections which follow.

5.6.1. Vision of mathematics at Key Stage One

In order to build an understanding of the perceptions of difficulty of participants at Key Stage One the children were asked whether maths is easy or difficult. Once they had given their response to this rather simplistic question, they were then asked to qualify their answer. In the section below, responses to the first question are analysed in Table 28, and illustrated with the ideas which participants used to support their answers.

As could perhaps be expected given the mercurial nature of attitudes (Ruffell et al, 1998) participants did not always respond that they found mathematics consistently easy or consistently difficult.

Table 28-Frequencies of Key Stage One participants agreeing with each 'vision of mathematics

Vision of mathematics	Number of participants who agreed with this statement
Mathematics is easy	6
Mathematics is difficult	4
Mathematics is sometimes easy and soemthimes difficult	12

By far the most popular answer given by participants was that they found mathematics to be ‘sometimes easy and sometimes difficult’. The final possible category ‘Mathematics is between easy and difficult’ could reasonably be clustered with the ‘mathematics is sometimes easy and sometimes difficult’ categorisation, meaning that more than half of the participants interviewed had a changeable view of how difficult they found mathematics. Conversely, six participants considered mathematics to be easy, and four perceived that it was difficult. If these responses are clustered, which would be reasonable as all of these respondents had a definite idea of their own perceived difficulty of mathematics; ten participants had a binary ‘easy or difficult’ view.

When prompted further as to why they found mathematics sometimes easy and sometimes difficult, or why mathematics was ‘between easy and difficult’ participants universally responded with exemplar mathematical operations that they found harder than some of the other mathematical concepts that they had been taught.

Int: Do you think maths is easy or difficult?

Lucy: Sometimes easy, and sometimes difficult

Int: When is it easy, and when is it difficult?

Lucy: When it’s going in the three hundreds, it’s really hard to take away from that number

Int: When’s it easy?

Lucy: It’s easy when you’re adding really big numbers

Lucy-Y2-Interview

The excerpt above is a fairly typical illustrative answer from those participants who identified that mathematics was sometimes easy and sometimes difficult. Lucy shows an understanding that mathematics is not one single concept, but rather many related concepts.

Other participants responded that they found adding and subtraction easier than multiplication (although there were some differences in the ways in which participants described this particular construct; some called this ‘timesing’ and some called it ‘counting in threes’ for example).

Once the data had been analysed through the lenses outlined in the theoretical framework, it was then possible and appropriate to begin to identify the links between the variables which might ultimately lead to participants studying mathematics when it is no longer compulsory. In Table Twenty Eight below, the first of these links is investigated; whether those participants who found mathematics to be difficult liked it, and whether disliking mathematics or finding it difficult influence the decision not to study post-compulsory mathematics.

Table 29 – Links between studying mathematics when Key Stage One participants no longer had to and perceptions of difficulty

Anononymised Name	Would study mathematics when they no longer had to: Yes/No	Like or dislike	Is maths easy or difficult?
James A	M	D	D
Jess	Y	D	D
Darcey	D	S	ST
Abi	N	S	D
Milo	Y	D	D
Lily	Y	S	ST

Whilst the sample here is not big enough to claim any correlations positively, it is possible to look for links. Shown here in Table 29 is a partial matrix of those students who disliked, or sometimes liked mathematics. In all three instances where participants stated that they disliked mathematics, they also without question found it difficult. However, this was not a particular barrier to claiming that they would continue to study mathematics later in their educations. One responded that he might study mathematics when he no longer had to and two responded that they would continue in further mathematical study. The codes used here can be seen in the codebook in Appendix Four. Participants at Key Stage One did not necessarily feel that difficulty was a barrier to liking mathematics. Milo asserted how happy this attainment made him feel.

Int: How does learning maths make you feel?

Milo: *so happy*

Int: So happy. Why does it make you feel so happy?

Milo: Because I feel proud of myself after I've do it all.

Int: Ok, why do you feel proud of yourself?

Milo: Because I've done a good job.

Int: What makes you feel prouder: If you've done a good job in maths or a good job in literacy?

Milo: Literacy isn't really that tricky for me. All you're doing is writing and sometimes copying. But im maths it is sometimes quite hard because you're adding like bigger numbers. I don't find it quite tricky, but I don't like it much, but I do like when I see it when I've finished.

Milo-Y2-Interview

Milo recognised that mathematics was a 'tricky' subject, but that this meant that achieving in it and getting it right gave him a bigger sense of satisfaction than when he did his Literacy work.

5.6.2 Visions of mathematics of Key Stage Two participants

Participants at Key Stage Two were asked to consider to what extent they agreed or disagreed with the following statements: 'Maths lessons are fun', 'Maths is difficult', 'I find maths boring'. The extent to which their answers correlated with their school year can be seen in Table 29 below.

Table 30 – Correlation between Year Group at Key Stage Two and vision of mathematics

		Which school year are you in? -- --	Maths lessons are fun	Maths is difficult	I find maths boring
Which school year are you in? -- --	Pearson Correlation	1	-.173	.097	.119
	Sig. (2-tailed)		.215	.490	.393
	N	54	53	53	54

It is important to note that the correlations here are not particularly significant the strongest correlation was between school year, and 'Maths lessons are fun'. Whilst the correlations are arguably not statistically significant, there is some emerging evidence in this data set that students' perceptions of mathematics might become more 'negative'. Whilst relationship between the 'positive' aspects of vision of mathematics (i.e. mathematics is fun) appears to have become more negative with a Pearson correlation of -.173 as students progress further through their mathematics educations. In comparison, again whilst arguably not statistically significant the relationship between school year, and those variables of ‘vision of mathematics which could be considered to be ‘negative’ appears to be more positively correlated. A correlation of .097 is observable between school year and a perception that mathematics is ‘difficult, as well as a correlation of .119 between school year and finding mathematics boring.

There was some supporting evidence from some participants in the long answer questions which concluded the questionnaire. Three students said that they ‘struggled’ with mathematics. All three students noted that it ‘made them feel bad’, and also impacted upon their perception of mathematical self-concept. However, an idea that mathematics is difficult does not necessarily lead to a participant not liking mathematics.

Int: How does learning maths make you feel?

Tom: I feel really good when I get it right and when I get stuff wrong I feel next time I’ll get it right. I’ll try again and get it right.

Tom-Y6-Interview

As can be seen in the section above, participants did not view mathematics as difficult all of the time. The most common answers given to the interview question is mathematics easy or difficult was that mathematics was sometimes easy and sometimes difficult. This appeared to depend on the particular mathematical principals which were being taught;

Rosie: I love it

Int: You love it. What do you love so much about it?

Rosie: Because I like adding up and taking away and dividing and timsing numbers all the numbers and doing fractions

Int: OK. Is maths easy or is maths difficult?

Rosie: Maths can be quite difficult when you get on a higher step and it gets really hard like when you have to add a four digit number and a three digit number

Rosie-Y4-Interview

There was also evidence from participants at Key Stage Two that perceptions of difficulty were not necessarily fixed, as can be seen in the extract from Eddie’s interview below.

Int: So how do you know that you’re doing well?

Eddie: I've been getting standard, like full marks out of some tests but I'm not sure when we're not doing tests and when we're just learning new things like when it came into dividing I was still I didn't know a clue about it before but I'm quite confident about it now and it's the same with fractions still not entirely sure about it but I think I will

Eddie-Y2-Interview

As can be seen in the above conversation with Eddie, his confidence has grown based on his previous experiences. He doesn't understand fractions at the moment, but because of his prior experience of not understanding dividing, and then having some success in learning it he is happy that even though he doesn't understand a concept now he probably will in the weeks to come.

5.6.3 Vision of mathematics at Key Stages Three and Four

As per the analysis of Key Stage Two data correlations were drawn between participants' desires to study mathematics, at A Level, and their feelings about whether mathematics lessons are fun, whether they enjoy mathematics, and whether they feel mathematics is difficult. These factors are analysed in Table 30 below.

Table 31- Correlations between participants' desire to study Mathematics at A-Level, vision of mathematics and vision of mathematics at Key Stage Four

		Do you plan to study mathematics once you leave secondary school? -- --	Maths lessons are fun	Maths is difficult	Maths is boring
Do you plan to study mathematics once you leave secondary school? -- --	Pearson Correlation	1	.442**	-.215*	-.333**
	Sig. (2-tailed)		.000	.038	.001
	N	95	93	93	93
Maths lessons are fun	Pearson Correlation	.442**	1	-.374**	-.527**
	Sig. (2-tailed)	.000		.000	.000
	N	93	93	91	91

There was a reasonably strong correlation between planning to study mathematics and finding mathematics lessons fun and intending to study it in post-compulsory education at .442. There were some lesser negative correlations between the intention to study post-compulsory mathematics and finding mathematics difficult at -.215 and finding mathematics boring at -.333. It is perhaps worth considering that since the correlation between finding mathematics difficult and the intention to consider studying it is relatively small, perhaps even those who enjoy mathematics and intend to take it at A-Level do not find all mathematics easy all of the time, and realise that some mathematics is difficult.

When talking to the interview participants, it became clear that their vision of mathematics was highly complex. Participants were asked whether mathematics was easy or difficult. With only one exception (A Year 7 student who replied that mathematics was difficult) all participants responded that mathematics was sometimes easy, and sometimes difficult. With only one exception (of a student who commented that the difficulty of mathematics depended upon the effort that they put in to completing mathematics problems) the rest of the participants who responded that mathematics was sometimes easy and sometimes difficult felt this was dependent upon subject content.

Cindy in Year 9 had completed her Primary school education in Hong Kong, and the first year of secondary education in a private school some distance away, but her response was still fairly typical of respondents in this cohort.

Int: Is maths easy or is maths difficult?

Cindy: It depends on the topic. Right now, I find everything hard right now because it's GCSE and it's hard for me and also it's, it really depends on the topic. If I found it hard I would just go home and practise it.

Cindy-Y9-Interview

There was no particular agreement among participants as to which parts were easy and which were hard, even amongst those participants in the same year groups. This is potentially because of the use of setting, with students in different sets being taught different topics. Whilst one Year 9 participant responded that he found congruency to be the most challenging, a Year 11 student approaching her imminent GCSE examination responded that she struggled the most with ratio. On occasion, the perceived difficulty of mathematics was determined simply by how a student was feeling on a given day.

Int: Is maths difficult or is maths easy?

Jacob: Difficult

Int: What bits are difficult?

Jacob: Practically all of it. Sometimes if the day's good, maths can be quite easy for me, but if the day's bad, like you didn't get enough sleep or something, it can be really difficult.

Jacob-Y7-Interview

Jacob reported that how difficult he finds mathematics depended on occasion on whether he had enough sleep. He was in Year 7, and was therefore one of the younger participants in the Key Stage Three sample.

In common with participants at Key Stages Two and Three, a perception that mathematics was difficult did not necessarily imply that students did not like mathematics or find it worthwhile.

Int: Ok. If you could choose three words to describe maths, what would they be?

Tony: Hard

Int: So what is it you like about it if you find it hard?

Tony: I just like trying to learn everything!

Tony-Y7-Interview

Amongst interview participants, there was a perception that they liked that their answers in mathematics were either ‘right or wrong’.

In a number of interviews, students expressed that they preferred mathematics to English because they liked that they could either be right or wrong. In the exert below, Lucan explains why.

Int: You said in your online survey that when you don’t have to study maths anymore you’ll probably keep doing it.

Lucan: Yep

Int: So can you tell me a little bit about why that is?

Lucan: Just because I understand it. It’s simple, it makes sense, it’s logical. Not much else to say. It’s not like English where there’s multiple answers. I just find it easy.

Lucan-Y9-Interview

Lucan makes clear here his preference for mathematics over English. He expresses that the reason that he prefers Mathematics is that answers are right or wrong. This was a position echoed by a number of interview participants across the Key Stages. Whilst this study does not attempt to research any aspect of the teaching of English, this is certainly a point worth considering.

Again, the vision of mathematics presented by participants was at least in part related to the content of their mathematics lessons.

Int: One day when you don't have to do maths anymore, are you going to do it or are you going to not do it?

Joe: I'm going to not do it.

Int: Why are you going to not do it?

Joe: Because it's boring

Int: It's boring. What's boring about it?

Joe: It's repetitive

Int: So when you say it's repetitive, what kinds of things are particularly?

Joe: The methods and stuff are always the same thing and it's hard to remember everything

Joe-Y9-Interview

Joe in Year 9 was frustrated with mathematics. The major theme emerging from the interview with Joe was that he was bored due to the repetitive nature of what he needed to learn. He had a specific set of methods which were one day going to be useful for his GCSE examination.

5.7 Normative influences

Questions in this part of the thesis were asked in two sections in order to gather data on the normative influences upon participants. Firstly participants were asked to consider who they would ask when making important decisions about school. They were then asked to imagine a school subject which they did not want to do (in order to account for those students who had already expressed that they wished to continue to study mathematics when they no longer had to); and then asked to consider whether they would do it if their parents wanted them to, if their teacher wanted them to and then finally if their friends were going to do it.

Noticeable throughout the responses of participants at all Key Stages was the influence of teachers upon decision making with regard to the pursuit of post-compulsory mathematics; with a median Likert response of a 4 in response to the statement 'I would do mathematics if my parents wanted me to' across most of the questionnaire data with the exception of Year 11 participants. This is explored more thoroughly in each of the Key Stage sections below. Participants in Key Stages Three and Four had a noticeably more complex circle of influence than those at KS1 and KS2.

Table 32 – Normative Influences by Year Group on participants in Key Stages Two, Three and Four

	If my teachers thought I should do maths at A-Level, I would think about it	If my friends were going to do maths at college, I would too
Year 4	4	4
Year 6	4	3
Year 7	4	2
Year 9	4	3
Year 11	3	2

5.7.1 Normative influences on Key Stage One participants

In the section which follows, the specific normative influences on Key Stage One participants are explored. This is a separate section to the analysis presented above as the means of data collection was purely by semi-structured interview.

5.7.1.1 Influences of parents, teachers, friends and others when making important decisions about education

At the beginning of this part of the interview, participants were asked to think about the people who they would ask when making important decisions about school in general, with the example given being 'If you needed to make an important decision about school, for example if you could go on a school trip, but you were not sure if you wanted to go or not, who would you ask to help you to decide?' Table 33 below shows the free choice answers of the participants. In this instance, there are more than twenty two responses as a small number of participants chose to mention more than one person who was important to their decision making process.

Table 33 – Frequencies of Key Stage One participants choosing each normative influence when asked who helps them to make important decisions about school

Person	Number of participants
Friend	2
Parent	10

Teacher	9
Don't Know	3

In this area, the normative influence of friends was noticeably smaller than those of adults, whilst the normative influences of parents and teachers were relatively similar. In this area, participants were less able to articulate why they made their particular choices. In general, students were more likely to choose the adults because of a perception of 'wisdom', they simply perceived that their teachers and parents would know what was best for them. A smaller proportion of participants chose parents and teachers as their person to go to for advice, but cited that they would want to 'Do as they were told' as the reason for doing so.

5.7.1.2 Relative influences of parents, friends and teachers when deciding specifically to study maths

Once participants had stated who helped them to make important decisions about school without any suggestions from the interviewer as to who these might be, they were then prompted to respond as to whether they would continue to study mathematics (or if they had expressed a strong liking for mathematics throughout the interview, they were asked to consider a subject that they didn't like) if their friends were going to do it, if their parents wanted them to do it, and if their teachers wanted them to do it. In each of the cases of potential normative influence (parents, teachers and friends) was tagged as being either 'influential' or 'non-influential'. A code was also included for 'Don't know', but its use was minimal in this instance. It was then possible to build a conceptually clustered matrix, part of which is shown in Table 34 below.

Table 34 – Frequencies of Key Stage One participants agreeing the normative influences of key people

Person of potential influence	Influential	Not influential	Don't know
Friends	9	12	1
Teacher	19	3	
Parent	16	5	1

Once the relative influence of each of the three possibilities had been established, then the conversation moved to the reasons why each of the three possible normative influences exerted its impact on potential future decisions of the participants. The reasons given by the participants for the impact of each normative influence are analysed in the sections that follow. The reasons for the impact of the normative influences were not analysed using any particular lens from the theoretical framework, as this idea had not been explored in the theory or the literature in any depth. Therefore an inductive approach to analysis was employed, with themes emerging from the data used to generate the possible tags e.g. the theme of ‘parental authority’ was not originally part of the theoretical framework, but emerged following the tagging of interview data.

5.7.1.3 The normative influences of parents on Key Stage One participants

Of the twenty two participants, sixteen responded that they would continue to study mathematics if their parents wanted them to, as can be seen in Table Thirty Four above. Their reasoning of how they arrived at this conclusion can be seen in Table Thirty Five below.

Table 35 – Reasons given by Key Stage One participants for the normative influence of parents

Parental Authority	14
Parental Wisdom	1
Other reason for parental influence	1

As is evident in Table 35, when prompted as to why parents had such a strong normative influence on their decisions on which subjects they might study when they were no longer compulsory, participants overwhelmingly reasoned that perceived parental authority was enough reason to continue to study a subject even if they did not particularly like it. The response below by James was fairly typical of the participants in the sample.

Int: Yeah, ok. What about if you really didn’t want to do maths, but your mum said ‘James, you’re so good at maths I really want you to do it’ Would you do it or not do it?

James A: I would just stick up for it if mum wanted me to do it

Int: Yeah, why’s that?

James A: Because I do whatever my mum says. Unless it’s something stupid.

JamesA-Y2-Interview

James’ response here is not based on any particular reason why he does what his mother says, but simply that it is what he habitually does.

5.7.1.4 Participants' voluntary contributions on the normative mathematical influences of their parents

The normative influence of parents and other adults was observable not only in the responses of participants to questions specifically designed to capture data on this particular phenomenon, but as a theme in other parts of the interviews.

Int: How important do you think that numeracy is outside of school? Do you use any numeracy?

Jess: *Nods*

Int: Yeah? What do you use it for?

Jess: Well…..sometimes because my Dad's really good at maths I get him to write it down and then I work it out. And he ticks them if I get them correct.

Int: Like a teacher?

Jess: He's a chimney sweep.

Jess-Y2-Interview

Like many of the participants, Jess identified that she likes to do 'challenges' using mathematics outside school. However Jess identified here that the challenges were set for her by her father, although his job is arguably not particularly mathematical in nature. There was also some evidence of parents encouraging participants less directly to improve their mathematical skills.

Kia: I've got a unicorn at home that my mum bought me to count with.

Int: A unicorn?

Kia: I don't know how to say it. They're these things with like holes in, the ten would have ten holes in. And then you can make different numbers with them.

Kia-Y2-Interview

Kia's mother has not tried in any way to influence whether or not Kia likes mathematics, or might study it at a later stage. What is evident however, is that she is taking an active interest in Kia's mathematical education. Perhaps, simply in this active participation she could be considered to be exerting a normative influence. Parents were not the only adults who inspired participants, as participants voluntarily discussed their wider circle of influence. In the excerpt below, Ruby discussed the influence that her uncle had on her interest in mathematics. She clearly thought this point pertinent enough to bring up without any prompting from the interviewer as to whether she had any other external influences on her attitude towards mathematics.

Ruby: Because I really like doing it, and who got me into maths is my uncle.

Int: Yeah?

Ruby: Because he really likes maths as well.

Int: So what things did he do to get you into it?

Ruby: Well, he showed me this, well he showed me this book which had loads of like calculations and sort of division and multiplication and subtraction and addition. Things like it was a dictionary of maths dictionary.

Int: Yeah? And it was just really interesting was it?

Ruby: Yeah and it was when I was in Year R, he showed me it, when I was four or five I kept doing like, I didn't know I was doing it systematically, I wanted to make number sentences up to like 20 and I didn't know I was doing it systematically, but I ended up doing it systematically. Like starting from one zero then zero.

Ruby-Y2-Interview

Whilst Ruby's uncle is not one of the normative influences originally included in the interview questions, he certainly has had quite an impact on her love for mathematics at the age of seven.

5.7.1.5 The normative influence of teachers on Key Stage One participants

Following the discussion of the normative influences of their parents on their decisions to study post-compulsory mathematics, participants were then asked to consider if they would continue to study post-compulsory mathematics (or other subject that they disliked) even though they didn't want to if their teachers thought that they should. As can be seen in Table Three, teachers were the most impactful normative influence of the three possibilities. The reasons why are outlined in Table 36 below.

Table 36 – Reasons given by Key Stage One participants for the normative influence of teachers

Teacher Authority	8
Teacher Wisdom	3
Other reason for teacher influence	1

Similarly to the way in which participants constructed their reasons for the relatively high impact normative influence of their parents, most participants considered that teachers exerted an authority over their decisions. In particular, they did not want to get into trouble for disobeying their teacher. In the excerpt below, Eddie illustrates his respect for his teacher's wishes.

Int: What, if you don't do it? Ok. What about if you weren't going to do maths, but then Miss Shepherd said 'Eddie, you're really good at maths…

Eddie: *laughs*

Int: ….would you do it or not do it?

Eddie: Do it. Because then could move my peg

Eddie-Y2-Interview

In the Infants School which participated as the research site for this study, each student had a peg denoting where they were in terms of their behaviour. The teacher could move their peg depending on the behaviour of the student. Eddie then went on to provide several examples of times that his peg was moved due to shouting, 'being silly' and not working. He, like many others in the sample considered not doing what the teacher said 'poor behaviour'. This position was echoed by other participants in the sample.

Int: What about if your teacher really wanted you to do it? Would you do it or not do it?

Milo: Do it.

Int: Why would you do it?

Milo: Because I might get told off, and I know that I'm supposed to do it.

Milo-Y2-Interview

In contrast with the perceived wisdom of their parents, relatively more participants relied upon the wisdom of their teachers to help them make this particular decision since it was directly related to their teacher's knowledge of students as mathematicians. This is illustrated in the excerpt below.

Int: What about if you didn't want to do it, but your teacher said 'Alex, you're really good at maths' would you do it or not do it?

James B: I'd do it

Int: You'd do it. Why would you do it?

James B: Because my teacher's telling me to do it, and she knows that I'm good at it. She's older than me.

James B-Y2-Interview

In this excerpt James demonstrates with some clarity that his teacher knows that he is good at maths, although he does qualify this with the fact that she is older than him. In the excerpt below, Emily directly compares the relative influences of her teachers and parents.

Int: You would have company doing it. What about, if you got to 16 and you didn't want to do it anymore, but your mum said, 'Emily' or your dad said 'Emily, I really badly want you to do maths', what would you say?

Emily: No.

Int: Why would you say no?

Emily: Because I don't have to if I don't want to!

Int: What about if your teacher said to you 'Emily, you're so good at maths you should keep doing it because you would get a good grade. What would you do?

Emily: Do it.

Int: Why would you do it?

Emily: Because I would trust my teachers and what they said.

Int: So why if your dad said 'Do it' you wouldn't do it, but if your teacher said 'Do it' you would do it

Emily: Yeah.

Int: So why is that?

Emily: I think I would trust my teachers a little bit more.

Emily-Y2-Interview

Emily demonstrably values the opinion of her teacher more in this decision which is related to her schooling. She has a very definite idea that if her parents wanted her to study maths she would be unlikely to do so, but that she trusted her teacher more in this instance.

5.7.1.6 The normative influence of friends on Key Stage One participants

Finally, in this section of the interview participants were asked if they would continue to study mathematics (or another subject they didn't like if they had previously stated that they wished to study mathematics when they no longer had to)if all of their friends were going to do it. It should be noted that this question is subtly different to that asked in order to ascertain the influence of friends and teachers; which was 'Would you continue to study mathematics when you no longer had to when if your parents/teachers wanted you to keep studying it?'. The least impactful normative influence on the decision to study post-compulsory mathematics was friends. Whilst 16 participants would continue to study mathematics if their parents wanted them to, and 19 would continue to do so if their parents thought that they should, only nine participants stated that they would continue to study mathematics (or other subject that they didn't like) based upon the opinions of their friends. Whilst as can be seen in the sections above the reasons why these people had this impact were relatively polarised, more disparate reasons for the normative influence (or not) of friends.

Although only just over half of the participants gave enough of a reason why to allow for analysis, these reasons are still worthy of some considerations and can be seen in Table 37 below.

Table 37 – Reasons given by participants at Key Stage One for the relative normative influence of friends

Enjoys company of friends	4
Wants to do something else	1
Wants to make own decision	5
Friends help me	2

It is worth noting that in direct comparison to those reasons given as to why participants would continue to study mathematics or another subject that they didn't enjoy when they no longer had to, participants did not recognise any inherent authority in their friends. They felt no particular need to impress or to please their friends, and did not fear 'getting into trouble' from them. In those instances where participants would continue to study mathematics if all their friends were doing it, the majority said that they would do so because they enjoyed the company of their friends, or because they valued their friends' help in the classroom. One participant said that if all of her friends were going to do mathematics then she would to since 'if they can do it, then so can I!'. Conversely, the majority of participants were not influenced by their friends. When asked to consider why, most participants replied that they would rather do the subjects that they enjoyed.

5.8 Normative influences on Key Stage Two participants

Students from the Key Stage Two sample were also asked to consider their normative influences. In order to analyse the relative normative influences on participants of those closest to them (their friends, their parents and their teachers), those questions related to the potential normative influences were correlated with the intention to study mathematics at college.

Table 38 – Correlation between the desire to study mathematics and relative normative influences on Key Stage Two participants

Correlations

		I will probably study maths at college -- --	My parents encourage me to do my best in maths	If my teachers thought that I should do maths at college, I would	My parents are good at maths	If my friends were doing maths at college, I would too	My friends are good at mathematics
I will probably study maths at college -- --	Pearson Correlation	1	.194	.433**	-.042	.393**	-.011
	Sig. (2-tailed)		.161	.001	.765	.004	.940
	N	54	54	54	54	53	54

In agreement with participants at Key Stage One, participant in Key Stage Two were likely to assert that their parents and teachers 'knew what was best for me' as can be seen in the extract from Carmen's interview below.

Int: What about if you got to college, and you really didn't want to do English, but your teacher really wanted you to do it. Would you do it, or would you not do it?

Carmen: Mmm. I probably, errrmmm….maybe I would because like my parent they know what's best and they have a lot of experience for things like that and choices like that

Carmen-Y6-Interview

Carmen had commented that her worst subject was English, but that if her teacher thought that she should do it then she probably would. The reason that she gave was that she thought her teacher and her parents knew her and that they had experiences that would help them to make an informed decision.

Teacher feedback also proved valuable to participants in their formation of self-concept. This is demonstrated in the conversation below with Harriet who was in Year 6.

Int: Yeah, good. How are you doing in mathematics?

Harriet: I think I'm alright but I'm not the best maths person in the class. But I'm at the standard, and I'm doing ok

Int: You got your SATs yesterday

Harriet: Yeah.

Int: So you got expected?

Harriet: I think I got below, but my teacher said 'expected'

Harriet-Y6-Interview

Even though Harriet had just received the results of her Mathematics SATs exams, and attained 'Below expected', her mathematical self-concept was still fairly positive. This was because of the affirmation and feedback that she had received during the course of Year 6 from her teacher. For Harriet, her teacher was the expert whose feedback she valued even more than the feedback received from national arguably fairly high-stakes examinations.

5.9 Normative influences on Key Stage Three and Four participants

Explored in the following section are those normative influences which might impact upon the desires of students in Key Stages Three and Four to study post-compulsory mathematics. Likert items were included in the online questionnaire to assess the impact of teachers, friends and parents.

Table 39 – The correlation between decision to study post compulsory mathematics and normative influences Key Stage Three and Four participants

		Do you plan to study mathematics once you leave secondary school? -- --	My parents encourage me to do my best at mathematics	If my teachers thought I should do maths A-Level, I would probably think about it	If my friends were doing maths at college, then I would too	My teachers encourage me to do my best at mathematics	My friends are good at mathematics
Do you plan to study mathematics once you leave secondary school? -- --	Pearson Correlation	1	.193	.309**	.372**	-.209*	-.022
	Sig. (2-tailed)		.068	.003	.000	.043	.832
	N	95	90	93	94	94	95

It is important to note here that even the most significant correlations between normative influences and the desire to study post-compulsory mathematics could be at best described as moderate. In comparison with other factors explored in this sections (for example as can be seen in 'perceived exchange value') these factors are fairly negligible. The most significant influences according to the Pearson correlation measure were friends and teachers, with a correlation with the desire to study A Level mathematics of .309 for teachers, and .372 for friends. There was no particularly significant correlation with those Likert items designed to measure the impact of parents, but this was perhaps due in part to the way that the questions were asked. The impact of parents can be clearly seen from the responses to the long answer question 'Who helps you to make important decisions about your mathematical education?', which can be seen in Table 40 below. In Table 40 frequencies of tags from the analysis of the question are displayed. By far the most frequent influence of those mentioned by students is their parents.

Table 40 – Whole cohort normative influences defined by students in long answer responses Key Stages Three and Four participants

	Number of participants
My parents are influential	35
My Friends are influential	6
My Teachers are influential	19
My wider family is influential	10
My private tutor is influential	2
Nobody is influential on me, I make my own decisions	19
I don't know who is influential upon me	35

When tagging long answer responses for analysis, it became apparent that participants had a wider circle of influence than anticipated when designing the Likert-style questions. Whilst the Likert items addressed the arguably more obvious influencers (parents, teacher and friends) participants made reference to grandparents and brothers and sisters, but unlike participants in the KS1 and KS2 samples, made reference to the influence of private tutors. Some participants valued the contributions to their decision making of older siblings because of their similar experiences

‘My parents mostly and also my brother who is 3 years older than me and when it comes to the time when I have to decide he will already have done them so he could help me’

Harry-Y9-Interview

Some participants recognised that their brothers and sisters had made similar decisions, and might be following similar programs of study, and so thought them a reliable influence.

The significant impact of teachers upon decision making that can be seen in Table 40 was explained by interview participants. The most impactful people upon decision making amongst interview participants were their maths teachers, and students felt confident in their teachers expertise in helping them to take their next steps. Their reasoning is best explained by Alistair from Year 9.

Int: What about if there was a subject that you didn’t want to do at college, but your teacher thought you should do it?

Alistair: I would do it

Int: You would do it? Why would you do it?

Alistair: Because if my teacher thought I should do it, it would probably be a good thing to do

Int : Yeah. Why do you reckon that your teacher would know more than your mum though?

Alistair: Because they would have seen me in class, and they would know what I’m good at in class not just tests

Alistair-Y9-Interview

Alistair thought that if his teacher wanted him to do mathematics at A-Level, he would. His reasoning was that his teacher knew his capabilities, and in particular whether he was ‘good enough’. This perception was agreed by nearly all of the interview participants across all of the year groups.

Direct comment from their teachers was not always necessary in order for their teachers to have a normative influence on a participant’s vision of mathematics. As can be seen in the extract below, simply a change of teacher with different teaching methodologies could exert an influence on a student's beliefs.

Int: Are you like yay, oh my goodness I've got maths today, I can't wait to go to school, or are you like maths that sounds like I'm going to have a boring afternoon?

Mark: I used to enjoy it

Int: I used to?

Mark: We've got a new teacher now and she's not so good.

Int: Why is she not so good?

Mark: She just has a weird way of doing things

Int: Sorry?

Mark: She has a different way of doing things and obviously we're not so used to that.

Mark-Y9-Interview

He reflects that he used to enjoy mathematics, but doesn't at the moment because he has a new teacher. He does offer some hope that his attitude might change again, noting that this is potentially because he is not used to her approach yet. Again, this is a discrete experience within the context of his mathematics education, and whilst this will probably add to his beliefs and attitudes as a whole (Eagly and Chaiken, 1993, Fishbein 1967, McLeod, 1992) he may have further experiences which change his attitude again.

5.10 The affective dimension

In this section, correlations are drawn between the intention to study mathematics once participants leave secondary school and the affective dimension of attitude i.e. how mathematics makes participants feel. Because Key Stage One participants did not respond to a Likert questionnaire but to interview questions, it was difficult to translate their views to align precisely with those from the other Key Stages. For this reason, their responses are not included in this table. Analysis of their responses is explained in the paragraph which follows.

Table 41 – Components of affect by Year Group for participants in Key Stages Two, Three and Four

	I only do maths because I have to	Maths makes me anxious	I enjoy maths
Year 4	2	1	5
Year 6	2	2	4
Year 7	2	2	4
Year 9	3	2	3
Year 11	4	3	3

Miles et al (2014) propose that researchers should consider whether a study could benefit from a quantitative component. In this section, Key Stage One participants were asked to choose from a pictorial selection of faces. The faces ranged from 'Very sad' to 'Very happy' with a mid-point value of 'Okay'. It was possible here to assign numerical values to the faces, which could then be used in a Likert Style analysis. This was useful in giving an 'overall' picture of how much participants enjoy mathematics at this stage, and was appropriate since 'like' to 'dislike can be analysed more easily on a scale than the other more qualitative data presented here. Additionally, this provides a clearer mechanism for cross-sectional comparison later on in the study, when it is desirable to understand more about how attitudes towards mathematics change as participants move through their schooling. Whilst this approach would be simplistic in isolation, participants were asked in follow up questions to further describe their feelings, and to discuss why they had chosen their particular face picture.

To begin with, a simple matrix of participants' responses was built using Excel. This demonstrated the numbers of participants who had selected each face.

Table 42 – Frequencies of students at Key Stage one agreeing with each Likert item measuring affect

1 (So Sad)	0
2 (Quite Sad)	2
3 (OK)	5
4 (Quite Happy)	6
5 (So happy)	9
Mean response	4.4

The majority of participants selected either 'happy' or 'so happy' when asked how learning mathematics made them feel, with the greatest number of participants opting for 'so happy'.

The mean response on a 1-5 scale was 4.4, meaning that the majority of participants were somewhere between ‘happy’ and ‘so happy’ when learning mathematics.

Once students had selected their face picture and showed it to the camera, a discussion followed as to why they had made their particular choice. Whilst the initial matrix analysis and calculation of the mean response to the question may seem somewhat simplistic, the participants explanations of their choice were analysed in greater depth. Participants provided a variety of explanations, which were personal to them, for example Sam said mathematics made him happy because he found it useful.

Int: Pick which one is the best for how learning maths makes you feel?

Sam: So happy

Int: Why does it make you feel so happy?

Sam: Because it helps me through my life all the time

Int: It helps you through your life all the time

Sam-Y2-Interview

By contrast Darcey felt that sometimes mathematics made her sad. This extract would appear to support other evidence in the study that attitudes are mercurial and not fixed, and that these can be dependent on subject content.

Int: Ok. So if I said to you ‘How does learning maths make you feel?’ Which one would you hold up?

Darcey: hmmm…there isn’t an annoying one…I guess that one (a bit sad)

Int: A bit sad!

Darcey: Actually, that one (ok)

Int: So is it sometimes you feel a bit sad and sometimes you feel ok?

Darcey: Nods

Int: Why’s that?

Darcey: Because it depends what maths it is again. Because some maths is really hard, and some maths is nice and easy!

Darcey-Y2-Interview

5.10.1 Affective influences on the decision to study mathematics at Key Stage Two

Key Stage Two participants were also asked to consider how mathematics makes them feel, for example they were asked to what extent they agree with the statements ‘I enjoy maths’ and 'Maths makes me worried'. Again, this set of statements has been correlated with their school year.

Table 43 -Correlations between school year and components of affect on Key Stage Two participants

Correlations

		Which school year are you in? -- --	I enjoy maths	I like maths and science	Maths makes me worried	I find it difficult to make myself do my maths homework	Overall, I enjoy school	I only do maths because I have to	I like arts subjects (art, drama, music)
Which school year are you in? -- --	Pearson Correlation	1	-.127	-.272*	.130	-.050	.132	.111	.040
	Sig. (2-tailed)		.367	.049	.348	.721	.343	.424	.772
	N	54	53	53	54	53	54	54	54

The first factor with which correlations were drawn when considering the impact of year group on the affective dimension was whether participants perceived that they enjoyed mathematics. There was a noticeable albeit not particularly significant negative correlation between enjoying mathematics and becoming older. Similarly, there was a correlation of .130 between becoming older, and mathematics making participants feel worried. Again, it is perhaps worthy of consideration here that Year 6 participants were preparing at this point for a set of examinations which were presented to them as high-stakes. Year 6 students were also more likely to agree that they only did mathematics because they had to. Since the correlation between enjoying school and becoming older was positive at .132, this is perhaps indicative of a specific link between age and an increasing lack of enjoyment of mathematics.

5.10.2 Impact of components of affect on the decision to study mathematics at Key Stages Three and Four

Table 44 – Correlations between participants' intentions to study post-compulsory mathematics and their affective reactions to it at Key Stages Three and Four

		Do you plan to study mathematics once you leave secondary school? -- --	I enjoy maths	I like maths and science subjects	I like arts subjects (English, Art, Drama, Music)	Maths makes me anxious	Maths does not make me worry at all
Do you plan to study mathematics once you leave secondary school?	Pearson Correlation	1	.442**	.418**	-.236*	-.335**	.302**
	Sig. (2-tailed)		.000	.000	.022	.001	.004

The strongest correlation evident between those items designed to measure the impact of affective components of attitude and the intention to study post-compulsory mathematics was that of experiencing enjoyment, and liking mathematics and science subjects. The most dominant correlation in this section was between this intention and enjoyment of the subject at .442. There was an additional small negative correlation between a liking for arts subjects and this intention. A slightly stronger negative correlation (-335) between mathematics anxiety and a desire to study A Level mathematics was also evident. This correlation became stronger still between the specific intention not to study mathematics, and this is discussed further in 'Which of these factors is most dominant? 'section which follows. Because these correlations are fairly moderate, the relationship between how mathematics makes participants feel and the intention to study in post-compulsory education appears to be fairly complex. The correlation between 'Maths does not make me worry at all' and 'I will study mathematics when I no longer have to' is only .302, suggesting that even those who which to study mathematics at college worried about mathematics some of the time.

5.11 Mathematical self-concept

In the following section, the changing mathematical self-concept over time is considered

Table 45 – Mathematical self-concept of participants by Year Group for Key Stages Two, Three and Four median Likert items

	I am good at maths	I think that I am good at maths, but probably not good enough to study it at college	Lots of people in my class are better at mathematics than me
Year 4	4	3	4
Year 6	4	3	4
Year 7	4	3	4
Year 9	4	3	4
Year 11	4	4	4

As can be seen in Table 45 above, all participants had a relatively strong mathematical self-concept. However, at Key Stage Four they became more inclined to agree that whilst they were good at mathematics, they were perhaps not good enough to study it at college.

5.11.1Mathematical self-concept of participants at Key Stage One

In the next section, Key Stage One participants considered their mathematical self-concept. They were asked to think about whether or not they were 'good at mathematics', and how they had arrived at their conclusions.

5.11.1.1 What was the perceived mathematical self-concept of participants and why?

At the beginning of this section of the interview participants were asked whether they believed that they were good at mathematics or not. The results of this question can be seen in Table 46 below.

Table 46 – Frequencies of Key Stage One participants who agreed that they are good at numeracy

Good at numeracy	18
Not good at numeracy	3
Sort of good at numeracy	1

The overwhelming majority of participants perceived themselves to be good at mathematics. Eighteen participants considered themselves to be good at mathematics, along with one who considered herself to be 'sort of good' at it. Only three participants considered that they were not good at mathematics at all. The reasoning of participants as to why they had these perceptions of their respective mathematical capabilities is summarised in 47 below, which gives some general indication of how students at Key Stage One form their perceptions of their own mathematical self-concept.

Table 47 – Reasons given by Key Stage One participants for their mathematical self-concept

Some maths correct	2
Get answers correct	8
Able to carry out complex operations	4
Don't know	2
Feedback from teacher	1
Finds maths difficult	1
Does not find maths difficult	1
More able than others in class	3

If all the responses based on some kind of feedback (Getting answers correct, Getting some answers correct and feedback from the teacher) are grouped conceptually, it can be seen that half of participants (eleven of the twenty two interviewed) use this as the basis for forming their own ideas of whether they are 'good at mathematics' or 'bad at mathematics'. However, in order to make a more useful analysis, it is necessary to group those participants with a positive mathematical self-concept (i.e. they perceived themselves to be good at mathematics), and those with a negative mathematical self-concept. The reasons given by participants in these divisions, together with the numbers of participants who gave each response can be seen in Tables 48 and 49.

Table 48- Reasons given by Key Stage One participants for a negative mathematical self-concept

Anononymised Name	Good at numeracy	How do you know?
James B	N	SMC
Jess	N	DKWG
Milo	N	MD

Only three participants believed themselves to be 'not good' at mathematics; reasons cited were that one student perceived that they only sometimes got their mathematics correct, one perceived that they found maths difficult and that therefore they weren't good at it, and one did not know why they were not good at maths. One participant perceived that they were sometimes good at maths, again citing that they sometimes got answers correct. Some answers provided little evidence of how participants had formed this self-concept. In the extract below, Kia believes herself to be 'good at maths' because she does some at home.

Int: Don't know. Ok. Are you good at maths?

Kia: Yeah.

Int: How do you know you're good at maths?

Kia: Because I do it at home a little bit

Kia-Y2-Interview

Amongst this very small number of participants, it is difficult to see any pattern as to how they arrived at the conclusion that they were 'not good at maths'. These codes are available in the relevant codebook in Appendix Four. Conversely, the reasons given by those participants who had a positive mathematical self-concept as to why they believe that they are good at mathematics are shown in Table 49 below.

Table 49 - Reasons given for a positive mathematical self-concept by Key Stage One participants

Can carry out complex operations	4
Gets answers correct	8
More able than others in group	4
Feedback from teacher	1
Did not give a reason why	1

The most commonly cited reason given by participants for their positive mathematical self-concept was that they 'got the answers right'. Arguably these answers could be further clustered with that of the participant who relied on feedback from her teacher to make this judgement, making nine in total who's self-concept was predicated on 'getting answers correct'.

Students in Year 2 at the school were divided by previous attainment for mathematics, mirroring the streams and bands used in some secondary schools. Whilst they still worked in the same classroom, they moved to tables with others of similar previous attainment. Those working towards the top end of possible grades on the SATs examination worked on 'more complex' tasks. Students in this sample were already showing an understanding of where they were in the 'hierarchy' of their classroom. For four students, the understanding that they were 'better' than others in the group formed the foundation of their confident mathematical self-concept. This could be clustered conceptually perhaps with the four students whose self-concept was informed by their perceived ability to carry out complex operations, as is evident from the extract below in Richard's interview.

Int: Are you good at maths?

Richard: Yeah, really good.

Int: How do you know you're really good at it?

Richard: Because my teacher said I'm good, but when back in September they said I wasn't so good at long divisions, but now I know the divisions how many numbers were inside like the group, so I counted them and put that answer instead, instead of how many groups there are.

Richard-Y2-Interview

Whilst at this stage in education the understanding of this type of hierarchical classroom structure based upon prior attainment appears to be instrumental in forming a positive mathematical self-concept rather than reinforcing a negative one, this is perhaps not true in the later stages of compulsory mathematics education. This possibility will be explored later in the thesis with participants who have progressed further.

There was also evidence that at this stage in their educations, students were using teacher feedback to form the foundations of their mathematical self-concept, as is evident from Portia's interview

Int: I like her. Are you good at maths?

Portia: Yeah.

Int: How do you know that you're good at maths?

Portia: Because mostly I get green, but sometimes I get red. Like a question mark because it might be the wrong thing, so I have to go over and check it.

Int: But mostly you get green.

Portia: Yeah

Portia-Y2-Interview

Portia has used her teacher's marking to decide that she is 'good' at mathematics. Again, this means of informing self-concept is explored for other Key Stages later in this study.

5.11.1.2 Is there a link between a positive perceived mathematical self-concept and the intention to continue to study mathematics at Key Stage One?

From such a small sample, it would be disingenuous to claim any definite links. This issue is further polarised by the initial response from so many participants that they would continue to study mathematics when they no longer needed to. However, since one of the principal aims of this is to understand how the factors of affect identified in the theoretical framework affect the intention to study post-compulsory mathematics, it is reasonable to attempt to from some tentative links.

5.12 Mathematical self-concepts of students at Key Stage Two

Key Stage Two participants were also asked to consider how mathematics makes them feel, for example they were asked to what extent they agree with the statements 'I enjoy maths' and 'Maths makes me worried'. Again, this set of statements has been correlated with their school year.

In this section the perceived mathematical self-concept of the participants is analysed. Those statements addressing how 'good' or otherwise participants consider themselves to be are compared with participants' intention to study mathematics at college are considered with the likelihood that participants will study post-compulsory mathematics.

Table 50 – Correlations between factors of perceived mathematical self-concept and the desire to study post-compulsory mathematics at Key Stage Two

		I will probably study maths at college -- --	I am good at maths	I think that I am quite good at maths, but maybe not good enough to do it at college	Lots of other people in my class are better at mathematics than me	I am good enough at maths to study it at college
I will probably study maths at college -- --	Pearson Correlation	1	.388**	.032	-.166	.352**
	Sig. (2-tailed)		.004	.817	.231	.009
	N	54	53	54	54	54

At Key Stage Two when using the combined data gathered from both year groups, the strongest correlation with the desire to study mathematics from those items related to mathematical self-concept was the perception that participants were good at mathematics followed by the perception that they were good enough to study it at college.

Table 51 – Frequencies of students at Key Stage two agreeing with each Likert score for the statement 'I am good at mathematics'

I am good at maths

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.7	1.9	1.9
	2	7	12.1	13.2	15.1
	3	9	15.5	17.0	32.1
	4	21	36.2	39.6	71.7
	5	15	25.9	28.3	100.0
	Total	53	91.4	100.0	
Missing	System	5	8.6		
Total		58	100.0		

Students at Key Stage Two from both year groups had a very positive mathematical self-concept, with most participants either agreeing or strongly agreeing that they were good at mathematics.

When asked how they had arrived at their views of self-concept, the most common answer given by Year 4 and Year 6 Key Stage Two participants was feedback from their teacher in terms of the statements 'Expected', ''Below Expected' and 'Above Expected' as given in response to tests given to them by their teachers, although some Year 6 participants made use of their school reports and recent SATs examination scores.

Int: Ok. How are you doing in maths?

Lauren: Well, right now…Yesterday I got my report and it said 'Above expected'

Int: Wow! That's brilliant. I was really happy with that.

Lauren: I haven't looked at my SATs results yet

Int: Why haven't you looked yet?

Lauren: I don't know, I just didn't really want to right now. It's just a bit scary.

Lauren-Y6-Interview

In the excerpt above, Lauren had provided a typical response. She has used teacher feedback to arrive at her self-concept, but also considers her SATs results. She has attached importance to them, having not opened them yet because she needs to wait until she is ready. In addition, participants were also aware of the practice of setting within their classroom.

Int: Ok. How are you doing in mathematics?

Ellie: Good

Int: You're doing good. How do you know you're doing good?

Ellie: Cause I'm on one of the highest tables in maths

Int: Ok you're on one of the highest tables, so you're sorted out into tables are you? How else do you know that you're doing good in maths?

Ellie: Because most of the time when we're doing things I start on the ….on one of the…some people who don't understand it that well start on step one, people who do understand it and are not too sure as well go on step two

Ellie-Y4-Interview

The impact of this practice upon mathematical self-concept is explored in relation to the literature in the discussion chapter.

5.12.1 Mathematical self-concept of participants at Key Stages Three and Four

In the following section Key Stages Three and Four participants' mathematical self-concept (their perceptions of their own mathematical capabilities) is explored. In order to explore the impact of this, the intention to study mathematics is correlated with five Likert items designed to gather data about how participants feel about their mathematical 'abilities'.

Table 52– Correlations between participants' intention to study mathematics in post-compulsory education and their mathematical self-concepts at Key Stages Three and Four

		Do you plan to study mathematics once you leave secondary school? -- --	I am good enough to study maths at A level	I am good at maths	Lots of people in my class are better at mathematics than me	I think that I am quite good at mathematics, but probably not good enough to do it at college
Do you plan to study mathematics once you leave secondary school?	Pearson Correlation	1	.471**	.322**	-.247*	-.453**
	Sig. (2-tailed)		.000	.001	.017	.000

As is evident in Table 52 there are some clear correlations between the intention to study mathematics when participants leave secondary school and a belief that one is good at mathematics. Whilst this is arguably predictable, the data suggests that the situation is nuanced. There is a moderate correlation between the belief that one is 'good at mathematics' and the intention to study it when one leaves school, and the belief that one is 'good enough at mathematics to study it at A Level' and the same intention. Whilst the correlation between the intention to study mathematics at college and believing that one is 'good at mathematics' is .322, the correlation with the 'belief that one is good enough to study mathematics at college' is stronger and .471. This is further supported by the relatively strong negative correlation between believing that one is 'quite good at mathematics but not good enough to study it at college', and the intention to do so.

Similarly to those students in Key Stage Two, students showed an awareness of which set they had been placed in for mathematics, and made use of this to inform their mathematical self-concept. In response to the long answer item 'How do you feel about your mathematical ability? Why is this?' five students from across all of the year groups described the impact that setting had on how good they thought they were at mathematics. The first was David, who stated that

'I feel good about my maths ability as I am in the top set in the year group'

David-Y7-Interview

In Year 9, Toby discussed how at the age of 13, and in Year 9 he had received a Grade 4 in a class exam, and that he was 'really nervous' about this. The impact of this can be seen discussed in the excerpt below.

Toby: Good, except in my mock I only got a 4 but I think that's because I got really nervous

Int: Well, that's not so bad for someone in Year 9, is it?

Toby: No

Int: What grades were other people in the class getting?

Toby: Well, I was quite nervous because my friend who got 3.5 went down a set which I didn't really want to, and other people got sevens and stuff but they're the really clever people

Toby-Y9-Interview

It is important to note here that a Grade 4 is the benchmark grade required by post-16 students on entry to college if they are not to be compelled to re-sit their GCSE Mathematics and English examinations. This is the expected grade at 16 years old, so to be receiving this grade at the age of 13 as a Year 9 student is actually quite an achievement! However, to Toby the grade he had received in this low-stakes examination actually had quite a large exchange value. It had made him nervous that he might be compelled to moved down a set. According to a number of theories, attitude is built upon experiences. And according to some of the findings of this study the perception that one is 'Good Enough' to study post-16 mathematics is a factor with a moderate correlation to do so. The process here of setting by prior attainment is a demonstrable cause of anxiety to Toby, and therefore should perhaps be considered carefully when trying to increase the motivation of students.

The impact of assessment was also evident in response to the same question, with four students from across all year groups making reference to testing. For Harry in Year 7, both of these factors made him feel good about his mathematical ability.

'I think I am good at maths because I have always been in the top sets and have got good scores in all my tests.'

Harry-Y7-Interview

However, the association of being in the top set was not always positive. Amy felt that her place in the top set was not deserved, and appeared to almost believe that she did not deserve to be there.

'I feel I am awful at maths I might be in the top set but I don't feel confident in it so I would rather go down a set as some things I really struggle to learn'

Amy-Y11-Interview

Again, this is evidence that the relationship that participants have with their mathematical self-concept is highly complex, in this instance indicating that previous mathematical attainment is not always an indicator that a student might feel confident enough to study mathematics at A-Level. In this instance the normative influences of the student were also negligible with Amy asserting that even though everybody in her house was good at mathematics she would not be studying it at A-Level and that nobody could change her mind. By contrast, Lucy believed that she was 'bad' at mathematics, but that this idea was not necessarily fixed. As is evident from the interview quote below, Lucy's perceived continuous receipt of 'bad grades' had led her to dislike mathematics.

Lucy: Just because…just because I don't get the good grades I think that I'm never going to improve because consistently had bad grades in maths. If I just suddenly got really good I would probably like it.

Lucy-Y11-Interview

In discussion with interview participants it was also evident that students used their performance in assessments (or in the case of Year 11 students on their performance in past papers). This can be seen in Table 53 below.

Table 53- Frequencies of interview participants who made use of past papers to inform their mathematical self-concept at Key Stages Three and Four

Year Group	Use of assessments to inform mathematical self-concept
Year 7	4
Year 9	4
Year 11	5

This is supported by interview data from Lizzie in the excerpt below. She has clearly made use of her past-paper performance rather than her own instincts to inform her mathematical self-concept.

Int: Ok. How are you doing in maths?

Lizzie: Most of the time I think that I'm doing it right, but then we get to mark like papers and stuff and I just find that I'm doing it wrong.

Lizzie-Y11-Interview

By contrast, Matt in Year 9 had formed a positive self-concept from his marked assessments.

Int: How do you know you're doing alright at maths?

Matt: Our exams and our grades and just kind of knowing yourself if you know what to do

Int: Ok, What grade did you get on your last one?

Matt: I don't know. I don't think we've got our tests back.

Int: So you've just done your spring assessment. Are you going for a 9?

Matt: Hopefully.

Matt-Y9-Interview

The culture of assessment was well inculcated at School X. Students all sat major assessments of all prior learning three times a year as well as smaller end of unit tests. Year 11 students had all completed a number of past papers. All of this work was evidently rigorously marked by their teachers with grades, comments and clear targets for improvement. Each student had a tracker document stuck to the front of their book. Participants didn't have any negative emotions surrounding the administration of this testing. They sat similar assessments during the same calendar weeks in all of their other school subjects, and commented favourably in the role this testing played in informing them of their achievements and in giving them the next steps to move forwards.

5.13 Are attitudes stable or are they fixed?

Arguably the most reasonable conclusion that can be reached from the analysis of data is that the relationship between participants and mathematics is incredibly complex. When asked to respond to the long answer item 'How important is mathematics to you and why' the overwhelming majority of Key Stage Four participants agreed that mathematics was either important or very important

However, in spite of a general agreement that mathematics is probably quite important for a variety of reasons including 'It is important to me at the moment so that I don't have to re-sit it at college', relatively few participants agreed that they would study it in post-compulsory education. It can be seen in the above findings that even participants who agree that they like mathematics and would study it when they no longer have to might worry about it occasionally. It was evident that an enjoyment of mathematics was a factor in the decision to study mathematics at A-Level, but not a particularly strong one, implying that some students might not enjoy mathematics all of the time but would study it anyway. This would appear to support those students from Key Stages One and Two who asserted that mathematics was sometimes difficult and sometimes easy, or that some elements of mathematics were enjoyable whilst some were boring. One participant in the long answer responses asserted that

'Maths is important to me but only if it is practical. However some aspects of maths I find pointless to learn as they hold no value or would give you any bonuses in later life'.

Sean-Y9-Long Answer Questionnaire Response

Indeed, some participants self-identified that a change in ability might be possible, and that they could 'get better' as can be seen from the quote from a students with a relatively negative mathematical self-concept.

'My maths isn't that great but hopefully if I study then I might become smarter but I will keep trying even if I'm not that smart'

Emily-Y7-Long Answer Questionnaire Response

This situation is mirrored in Key Stage Two. It was notable from responses to the Likert-style questions that in general participants across the two year groups did not find mathematics particularly difficult. The numbers of participants who agreed or disagreed with the item 'Maths is difficult' can be seen in the table below.

Table 54 Frequencies of participants at Key Stage Two choosing each Likert score in response to the statement 'Maths is difficult'.

The extent to which participants agreed with the statement "Maths is difficult"	Numbers of participants who selected each statement
Strongly Agree	7
Agree	9
Not sure	9
Disagree	17
Strongly Disagree	11

This picture became more complex when analysing the data collected during the interviews. The majority of participants were in agreement that they would study mathematics when they were no longer compelled to do so; they were also in agreement that mathematics is neither universally easy nor difficult. The most common response from interview participants (with seven out of the eleven respondents) was that mathematics is 'sometimes easy'. When questioned further, participants elaborated that their vision of the difficulty of mathematics depended upon the particular topics being taught.

Students gave some considered examples of some of the topics to be easier than others.

Int: That's your style. That's your thing is it? Is maths easy or is maths difficult?

Xander: Sometimes it's easy, but sometimes it's a bit tricky.

Int: Yeah, what things are tricky?

Xander: If I have to times a big number by another big number

Xander-Y6-Interview

Students were not in unilateral agreement as to which topics were easy or difficult. Other topics which were considered to be more difficult were ratio, algebra and multiplying by decimals.

For one participant, a move between schools had made a significant difference to her perception of the difficulty of mathematics, as well as her own mathematical self-concept.

Tanya: I do…I did….I did want to do maths when I didn't have to anymore if I don't have to

Int: You do want to do maths when you don't have to. So can you tell me a little bit about how you decided that?

Tanya: Ummm because maths is my favourite subject and I um it I used to find it quite difficult

Int: Yeah?

Tanya: But once I moved schools from my old school to here I found it easier

Tanya-Y6-Interview

This supports discussion from the literature that visions of mathematics, and the impact components of affect are mercurial (Ruffell et al, 1998) and not necessarily fixed. This is explored in greater depth in the discussion chapter.

In turn, these mercurial perceptions appeared to impact upon how mathematics made participants feel. But again, this is perhaps more complex than just feeling 'good' or 'bad'.

Int: How does learning maths make you feel?

Toby: I feel really good when I get it right and when I get stuff wrong I feel next time I'll get it right. I'll try again and get it right.

Int: So you don't give up

Toby: No.

Toby-Y6-Interview

For Toby, whilst learning mathematics definitely makes him feel good when he gets it right, getting it wrong doesn't necessarily lead to him feeling bad. In this instance, the participants sees 'failure' are a challenge, and becomes more determined to 'get it right' in future.

Similarly, There were some inconsistencies in attitudes towards mathematics within individual interviews in the Key Stage One data, which aligns with the theory that attitudes are highly mercurial (Rufell et al, 1998), This was most noticeable when comparing the attitudes of participants expressed on whether they would continue to study mathematics after it was no longer compulsory and why with their responses to the final interview question, which required participants to consider three words that they would use to describe mathematics. This pattern was noticeable in several individual interviews, pointing to a possible trend across the data.

In the shorter second part of the findings chapters, the dominance of the components of attitude explored above on the decision to study post-compulsory mathematics is analysed and examined. The impact of the findings from this chapter, and their empirical contribution to knowledge are explored in the discussion chapter along with the methodological and theoretical contributions, and what these might mean for future research and policy.

Chapter Six Findings – The dominance of the components of attitude on Decision Making

In the final section of the findings chapter, the third research question 'Which of these are the most dominant?' is addressed. The findings for this particular research question were perhaps the most complex. The relative dominance of the components of attitude are presented below by Key Stage, and then as an overarching comparison of the components.

In order to ascertain which of these factors is the most dominant two comparisons have been made. Comparisons have been made between Likert items representing all of the components of attitude from the theoretical framework and with items asking participants specifically whether they did, and whether they did not intend to study mathematics in post-compulsory education. Comparisons have been drawn between both those Likert items which could be considered to be representative of a 'positive' attitude towards mathematics and the desire to study it in post-compulsory education, and those which considered to be negative and the Likert score given for the statement 'When I leave school I won't do any more mathematics qualifications'.

The combined theoretical framework has been used here as a lens to analyse the data. As per the analysis and presentation of findings in the previous chapter, the behavioural intention component of Azjen's (1991) Theory of Planned Behaviour has been used in order to consider whether participants intended to study post-compulsory mathematics at all, and then the factors of attitude from Di Martino and Zan's definitions of attitudes towards mathematics (2009) are used to examine how participants decide their perceived behavioural control and normative influences which form part of Azjen's more general theory of how people decide whether or not to emit a behaviour.

6.1 Dominance of factors of attitude on the decision to study post-compulsory mathematics

As per the organisation of the previous findings chapter, the findings surrounding the dominance of the factors of attitude on choosing to continue to study post-compulsory mathematics are outlined below in order of Key Stage. The explanations here are shorter, as many of the reasons behind students' rationales for the attitudes expressed have been explored and explained thoroughly in the preceding chapter.

6.1.2 Dominance of attitudinal components at Key Stage One

Because the data gathered from Key Stage One students was solely interview data, direct comparisons are a little more difficult than those in the other three key stages. In order to make these links, frequencies have been used to compare numbers of those who agreed that they would study post-compulsory mathematics with each of the components of attitude defined in the theoretical framework. Students who said that they did not know if they would study mathematics when they no longer had to have been omitted from this comparison since participants from other Key Stages did not have this option. This is perhaps an unavoidable limitation of this particular approach to data collection. As the students who participated were so young, they could not be reasonably expected to sit for enough time to respond to every item that participants responded to in the other Key Stages.

These frequencies can be seen in Table 55 below, together with the relevant commentary.

Table 55 – Frequencies of participants who said that they would study mathematics and components of attitude at Key Stage One

Number of participants who agreed they would study post-compulsory mathematics and that it was useful for their chosen job	10
Number of participants who agreed they would study post-compulsory mathematics that they were good at numeracy	13
Number of participants who agreed they would study post-compulsory mathematics and that it was easy	4
Number of participants who agreed that they would study post-compulsory mathematics if their teacher said that they should	13
Number of participants who agreed that they would study post-compulsory mathematics and agreed that it made them either happy or very happy	13

It is a little more difficult to claim any direct correlations from participants at this age. They are unused to making their own decisions about education, and all of them needed to have an explanation that one day they would be able to use what subjects they studied and be able to drop others.

Three of the components of attitude as discussed in the theoretical framework evidently exert the same impact upon those students who agreed that they would study mathematics when they no longer had to. One of these was the influence of teachers upon the decision to study post-compulsory mathematics. Only eight participants who responded positively to the question agreed that their parents were influential upon their decisions. Conversely, two students who said they didn’t want to study mathematics when they no longer had to responded that they would if their teacher said that they should, citing that they wanted to please their teachers and that they had to do what their teachers said. For these reasons, the normative influence of teachers could be considered to be a relatively dominant feature when students are in Key Stage One.

Similarly, students who responded that they would study post-compulsory mathematics were more likely to agree that it made them either happy or very happy. There was no particularly dominant factor on these feelings of happiness. They ranged across feelings of satisfaction when they got it right, to mathematics being useful, to simply finding mathematics fun.

The third factor which those who agreed that they would study mathematics when they no longer needed to were in agreement over was the perception that they were good at numeracy. Thirteen students who said they would study post-compulsory mathematics also agreed that they were good at numeracy. This very positive self-concept is discussed in relation to both current research and also theory in more detail in the discussion chapter.

The factor with the second least influential impact upon participants' decision making was whether they thought that mathematics would be useful for their chosen career. Of the twenty-two students who participated only ten had precise ideas about what they wanted to be when they grew up. This is not surprising given their developmental stage, and is discussed in relation to the literature in the discussion chapter.

The factor with the least dominance over those students who said that they wished to study mathematics when they no longer needed to was a perception of difficulty. Only four of those who wished to keep studying mathematics agreed that it was easy. As discussed in the previous chapter the most frequent answer across all participants was that mathematics was sometimes easy and sometimes difficult. This theme is echoed across the findings from the other Key Stages.

6.1.3 Dominance of attitudinal components at Key Stage Two

Making direct comparisons about the impact of the components of attitude upon decision making regarding those students in the later stages is easier because of the quantitative nature of the online questionnaire data gathered. In order to make these direct comparisons, the correlations between a Likert item representing each of the components of attitude from the theoretical framework has been compared with the intention to study mathematics. Firstly those items which could be considered to represent a 'positive' disposition towards studying mathematics have been compared with the ambition to continue post-compulsory study, and then correlations have been drawn between this ambition and those dispositions which could be considered to be 'negative'.

Table 56 – Comparison of 'positive components of attitude towards mathematics correlated with the ambition to study post-compulsory mathematics at Key Stage Two

		I will probably study maths at college -- --	I am good at maths	Maths lessons are fun	I enjoy maths	If my teachers thought that I should do maths at college, I would	Maths will be useful for my life after school, but maybe not for my job	Maths will be useful for my job when I leave school
I will probably study maths at college -- --	Pearson Correlation	1	.388**	.357**	.348*	.433**	.083	.263
	Sig. (2-tailed)		.004	.009	.011	.001	.554	.054

The correlations drawn here use the combined results of Years 4 and 6 from the online survey since there were no statistically significant differences between the attitudes of students in Years 4 and 6, as discussed in the previous chapter. The strongest correlations evident in the data from the Key Stage Two sample as a whole were a positive mathematical self-concept, an enjoyment of mathematics and a perception that mathematics is fun, and the belief that if their teachers thought that they should study post-compulsory mathematics then they would probably do so.

Correlations between the mathematical self-concept of participants ('I am good at maths'), their perceptions of mathematics ('Maths is fun'), the affective dimension ('I enjoy maths'), were significant at .388, .357 and .348 respectively. The reasons given by participants for this are discussed at length in the previous findings chapter.

In comparison, correlations between normative influences (If my teachers thought I should do maths at college, then I probably would') and the intention to study post-compulsory mathematics were stronger than any other comparison in the analysis of data from Key Stage Two participants. Interview participants agreed that even if they didn't want to do a post-compulsory subject they might change their minds if a teacher told them that they should, as can be seen by this excerpt from an interview with a Key Stage Two participant.

Int: And that's fair enough. But if your teacher said 'You're so good at it you should definitely do it would you do it or not do it?

Maddie: Maybe if people encourage me

Maddie-Y4-Interview

For Maddie, even though she did not enjoy mathematics, or see a utility for it, she agreed that she would be open to considering it if her teacher thought that she should. The reasons why participants felt that their teacher were influential are their perceived authority and knowledge, as discussed in the preceding chapter. The implications of this very important factor for both mathematics teaching and beyond are explored in the discussion chapter which follows.

The attitudinal factor with the least correlation with whether a participant was likely to study mathematics was a perception of utility of mathematics for their futures, either for their life in general once they had left school or for their chosen careers. The very small positive correlation with future general uses was 0.83, implying that participants in general couldn't see the future utility of what they had learnt, and that other factors such as enjoyment were more important to them at this stage in their development. The potential impact of utility for their careers was slightly higher at .263, but this is not particularly statistically significant. It is important to compare this with those who directly expressed that they would not study mathematics when they no longer had to. This comparison has been made in Table 57 below.

The factors of a 'positive disposition towards mathematics will now be compared with those which could be argued to be indicative of a negative disposition are explored in the section which follows. 'Negative disposition' Likert items which are most directly comparable have been selected, for example 'I find maths boring' has been used as the 'inverse' of 'I enjoy mathematics'.

Table 57 – Comparison of 'negative' components of attitude towards mathematics correlated with the ambition to study mathematics at college at Key Stage Two

		I will probably study maths at college -- --	Maths is difficult	I find maths boring	I only do maths because I have to	I think that I am quite good at maths, but maybe not good enough to do it at college	Lots of other people in my class are better at mathematics than me	Maths makes me worried
I will probably study maths at college -- --	Pearson Correlation	1	-.328*	-.395**	-.455**	.032	-.166	-.231
	Sig. (2-tailed)		.016	.003	.001	.817	.231	.093
	N	54	53	54	54	54	54	54

When exploring the inverse Likert items, the strongest negative correlations with the intention to study post-compulsory mathematics were finding maths difficult at .328 and a feeling of boredom at .395. Whilst there were statistically strong negative correlations between these factors, it is important to remember that relatively few students expressed that they felt this way, as can be seen in the previous findings chapter. The factor with the strongest correlation with not having an ambition to study post-compulsory mathematics however, was the perceived exchange value. The Likert items used for comparison here were 'I don't think that I will need mathematics for my job when I grow up' and 'When I leave school I won't do any more maths qualifications'.

Table 58 – Correlation between no intention to study post-compulsory mathematics and perceived exchange value of mathematics at Key Stage Two

		When I leave school, I won't do any more maths qualifications	I don't think that I will need maths for my job when I grow up
When I leave school, I won't do any more maths qualifications	Pearson Correlation	1	.349*
	Sig. (2-tailed)		.011
	N	54	52

There was a moderate correlation between participants expressing no ambition to study mathematics and their perception that mathematics would not be useful for their chosen careers. It is perhaps possible then, that seeing no practical uses for mathematics is a stronger reason for students at this age not to study mathematics than a perception that it is useful being an indicator that a student will study mathematics later one.

6.1.4 Dominance of attitudinal components at Key Stages Three and Four

In the following section, similar comparisons are made for students in Key Stages Three and Four between the intention to study post-compulsory mathematics and the components of attitude which are representative of a 'positive' disposition, and then between participants having no desire to study mathematics when they no longer have to and the Likert items which could be considered to be indicative of a negative disposition. The comparisons made here use the whole secondary school cohort comprising both Key Stages Three and Four, because there were not any significant differences in correlations between the factors of attitude and the school year at Key Stages Three and Four.

Firstly, the relationships between the Likert Items indicative of a positive disposition towards mathematics are discussed. These can be seen in Table 59 below.

Table 59– Correlations between 'positive' components of attitude Likert items and the intention to study mathematics at Key Stages Three and Four

		Do you plan to study mathematics once you leave secondary school? -- --	Maths will be useful in my chosen career	Maths lessons are fun	I enjoy maths	If my teachers thought I should do maths A-Level, I would probably think about it	If my friends were doing maths at college, then I would too	I am good enough to study maths at A level
Do you plan to study mathematics once you leave secondary school?	Pearson Correlation	1	.489**	.442**	.442**	.309**	.372**	.471**
	Sig. (2-tailed)		.000	.000	.000	.003	.000	.000

In comparison with the correlations drawn from the Key Stage Two data, the perception that mathematics will be useful for their chosen careers appears to have significantly more impact upon the decision to study mathematics when participants are no longer compelled to do so. This provides some further answer to the research question 'How do the attitudes of participants change over time'. The most significant correlations with the intention to study mathematics were being able to see a value for mathematics in a chosen career and the belief that one was good enough to study mathematics at A-Level, followed by an enjoyment of mathematics and a belief that mathematics lessons were fun. By contrast, normative influences upon the decision were relatively negligible (although still moderately significant) with students prioritising the influence of friends studying mathematics over recommendations from their teachers. At interview, Niamh in Year 11 clearly prioritised her future aspirations over the opinions of her parents when considering which subjects she was going to pursue at A Level.

This is illustrated in the excerpt below, albeit in a conversation about English with Niamh in Year 11.

Int: So if there was English, say, and you didn't want to do it…

Niamh: Oh, my dad wants me to do it.

Int: But that's not happening?

Niamh: No.

Int: So why not?

Niamh: Errm…because I think that he might want me to do it, but I know what I want to do in the future and I would rather choose to subjects that I both enjoy and I can see myself doing in the future and would be useful for me

Niamh-Interview-Year 11

The normative impact of teachers appears to become less important to students as they move into secondary school, with a less strong correlation with the intention to study mathematics than is evident from the Key Stage Two data, again providing further insight into how the attitudes of students change over time.

Table 60– Correlations between 'negative' components of attitude Likert items and the intention to study mathematics at Key Stages Three and Four

		When I leave school, I won't do any more maths qualifications	Maths makes me anxious	Maths is difficult	Maths is boring	With the career path I have in mind, I don't need mathematics
When I leave school, I won't do any more maths qualifications	Pearson Correlation	1	.425**	.309**	.347**	.321**
	Sig. (2-tailed)		.000	.003	.001	.002

When comparing the inverse of this, and examining the factors on the specific decision not to study mathematics, by far the biggest contributing factor was a feeling of maths anxiety.

This was a more significant influence than finding mathematics difficult with a correlation of .425 compared with a correlation of .309 for perceived difficulty, this would imply that the difficulty of mathematics is not always the cause of participants' worries. The correlation between not wishing to study mathematics and not seeing a utility for it in their future was comparable with that of those students in Key Stage Two.

6.2 Summary

In this chapter the dominance of each of the components of attitude from the theoretical framework has been explored. The main findings of each Key Stage are summarised in the sections which follow

6.2.1 Key Stage One main findings

With very few exceptions, Key Stage One participants agreed that they would study mathematics when they no longer had to. They were likely to agree that it would be useful for their careers, even if they were not sure what they would like their career to be. In instances where they had chosen a potential career they were able to describe potential sensible uses of mathematics, for example on participant who said that he would like to be in the police said that mathematics might be useful for working out how many vans might be needed. They saw exchange value in mathematics and were able to describe occasions when mathematics was useful for their lives outside of school. The most popular occasion was its use for homework, but they were also able to describe how they used mathematics for play; for example describing its uses when playing with dolls or when scoring games with their families. They also described every day uses of mathematics in unexpected places, for example counting the spots on a ladybird. They were also able to describe uses by adults, for example at work and in everyday life such as for cooking and for shopping. The majority agreed that mathematics is sometimes easy and sometimes difficult. Some participants also expressed that the difficulty was part of the reason that they enjoyed mathematics. The majority of participants also agreed that they would continue to study mathematics when they no longer had to if their teachers thought that they should, with the authority of their teacher being the most commonly cited reason. Their friends were the least impactful influence on their decision making. The majority perceived that they were good at mathematics, and that they had based this perception on 'getting questions right'.

At Key Stage One, the most dominant components of attitude on the decision to study mathematics were if a teacher thought that a participant was good enough to study mathematics, and whether mathematics made them happy, with 13 participants who said that they would study mathematics who also expressed these two sentiments.

6.2.2 Key Stage Two main findings

Participants in Year Four were less likely than those in Year Two to agree that they would study mathematics when they no longer had to. They were slightly more likely to report that they enjoyed school than they were that they enjoyed mathematics (with mean Likert scores of 4.11 and 3.94 respectively). Most participants in Years 4 and 6 agreed that mathematics would be useful for their chosen careers, and that it was important in general. Participants in Key Stage Two also agreed with those in Key Stage One that mathematics was not always difficult, and that some components were more difficult than others. The majority agreed that they would continue to study mathematics if their parents or teachers thought that they should because they believed that their parents knew what was best for them. The majority of participants perceived that they were good at mathematics, but were unsure of whether they were good enough to study it at college.

At Key Stage Two, the strongest correlations with the intention to study mathematics were a belief that teachers thought that participant was good enough to study mathematics (.433) and enjoyment (.348). The strongest correlation with not wanting to study post-compulsory mathematics was a perception of boredom (.395).

6.2.3 Key Stage Three and Four main findings

Participants in Key Stages Three and Four were less likely to agree that they would study post-compulsory mathematics and were less likely than those participants in Key Stages One and Two to report that they enjoyed school or mathematics. The difference between enjoyment in school and mathematics was not statistically significant. By Year 11, participants were significantly less likely to agree that they would study mathematics when they no longer had to than those participants in Year 7. Whilst the majority of participants knew what they wanted to do for their chosen careers, but with a median Likert score of three, most were likely to agree that they didn't know whether mathematics would be useful for these. When analysing responses to long answer questions pertaining to the practical uses of mathematics, the answers provided by Key Stage Three and Key Stage Four participants were similar to those in the preceding Key Stages. They were largely limited to shopping and money. Their general vision of mathematics was similar to that of those participants in Key Stages Three and Four in that they did not believe that mathematics was either difficult or easy, but could be both depending on the particular concepts being learnt. Students in Key Stages Three and Four were also likely to agree that they would continue to study mathematics if their parents and teachers thought that they should, but had a wider circle of influence than those in the previous Key Stages. Whilst participants in the sample generally agreed that they were good at mathematics, Year 11 students were more likely to agree that whilst they were good at mathematics, they might not be good enough to study it at college.

At Key Stages Three and Four the strongest correlation between wanting to study post-compulsory mathematics was with a perception that it would be useful for a chosen career (.489) followed by enjoyment and a perception that mathematics is fun (.442).

Together with considerations of the findings on which components of attitude affected the post-16 decisions of participants and how, the dominance of the components of attitude will be considered in relation to the current literature and the future implications of the body of findings presented in this thesis are explored in the Discussion chapter which follows.

Chapter Seven – Discussion

7.1 Introduction

In this chapter the original contribution of this study theoretically is explored, and considerations made as to the uses of the theoretical framework presented here for wider exploration of developing attitudes towards both mathematics and other subjects. The original contribution of this study theoretically is explored, and considerations made as to the uses of the theoretical framework presented here for wider exploration of developing attitudes towards both mathematics and other subjects. The results of the data collection and analysis are discussed in relation to the literature. They are also considered in relation to those areas of education outside of mathematics.

This thesis aimed to answer three research questions. These were

1. Do the attitudes of school students towards mathematics differ at different ages, and if so, how?

2a. 'What are the factors which affect a student's attitude towards choosing to study Mathematics in post-compulsory education?'

2b. 'Which of these are the most dominant?'

7.2 Discussion of the findings of the study

The specific findings are now discussed. This discussion is presented in relation to each of the original research questions. Within the presentation of each research question, the specific themes emerging from the analysis of the data are discussed.

'What are the factors which affect a student's attitude towards choosing to study Mathematics in post-compulsory education?'

7.2.1 Perceptions of Difficulty

Whilst it is unarguable that participants in this study who did not have any intention to study post-compulsory mathematics were more likely to report that mathematics was 'difficult', it can't be ignored that there were different perceptions of how difficult mathematics was, whether it was always difficult and whether being difficult was necessarily a bad thing. Whilst Epstein's (2010) work was only conducted amongst older students nearly all the participants identified that mathematics was 'difficult' and required a lot of work, including those who were second year mathematics undergraduates, it would appear that some comparisons could be made with some of the views of participants in this study. The study presented here into how students across the range of ages examined would appear to lend some new contributions to the current knowledge.

It does not necessarily follow that if a student is to report that mathematics is difficult, that this equates to the student not liking mathematics, or that this would necessarily indicate that they would not study mathematics when they no longer had to. This perception was echoed across the entire sample. There was some agreement with this in the literature, Walls (2009) found that participants believed that figuring out something difficult was rewarding. Black et al (2009) found that in some instances participants found that difficulty was part of what made mathematics rewarding.

Bandura's (1982) theory of self-efficacy is discussed later in this chapter, in which it is asserted that repeated failure might lead to lower self-concept. The evidence presented in this thesis however would appear to suggest that it is perhaps the way that failure and challenge is viewed by students that is the key to positive mathematical self-efficacy, and therefore enjoyment. The notion of difficulty and its impact upon enjoyment is discussed in further detail in the following section. This is because as can be seen in the findings, singular components of attitude towards mathematics are difficult to separate. Whilst for some students difficulty means that they might find mathematics frustrating because of their repeated experience of failure, other students might accept their failure on some occasions and use it to learn and to understand that failing once won't necessarily lead to failing again.

7.2.2 Enjoyment of mathematics

The overall strongest correlation with the ultimate intention to study mathematics was the enjoyment that participants felt. This position of a strong sense of enjoyment and motivation in mathematics is evident in much of the literature. Epstein's undergraduates (2010) who had chosen to go beyond studying Mathematics A-Level reported a strong sense of enjoyment in the subject. A strong sense of enjoyment has an impact beyond motivation. It is suggested by PISA (OECD, 2013) that students who performed well in the PISA tests also reported a higher sense of enjoyment of mathematics. What is unclear from both PISA, and from the data presented here is whether the increased success in performance is due to a sense of enjoyment, or whether continuous good performance leads to enjoying mathematics more. Arguably, being repeatedly successful probably leads to a higher self-concept (Bandura, 1991) which could in turn lead to higher enjoyment.

There were a number of reasons given by participants in this study for enjoying mathematics, for example a feeling of satisfaction in getting something that they perceived to be difficult correct. This would appear to be in disagreement with some of the findings presented in other studies. Epstein et al (2010) found that students who said that they felt that mathematics was difficult were unlikely to want to study it in their post-compulsory education, and that in some instances the perceived difficulty of mathematics led students to hate it. The participants in Epstein et al's (2010) study associate this difficulty with not being able to understand the taught content; however in the findings presented in this particular research participants' attitudes towards difficulty did not appear to be fixed. Participants across Key Stages in the findings presented in the previous chapter generally reported that the difficulty of mathematics depended on the subject content being taught at particular stages. In some instances because participants could recollect prior occasions where they did not understand taught content but could remember that it had become clear to them with practise, they were not concerned about their lack of understanding of the current mathematical material. The most commonly cited reason for not studying mathematics in Noye's and Sealey's (2012) study was a perception of difficulty. In Black et al's (2009) study, particpants believed that the difficulty of mathematics made it fun, because of a feeling that if it was difficult, then it must be worthwhile. This is arguably echoed by Martinez-Sierra and Gonzalez (2017), who assert that if a student perceives mathematics as a goal to be met, then when they are successful, they feel pride. Whilst participants across Key Stages in this research were less likely to agree that they would continue to study post-compulsory mathematics if they found it difficult, it is important to consider that many of the factors presented here are dependent upon others, and none of these can be considered in total isolation. The perceived utility of mathematics and self-concept were more meaningful indicators of whether a student was likely to want to study post-compulsory mathematics in terms of correlation with this intention.

7.2.3 Normative Influences

The key normative influences considered in this thesis were parents and carers, teachers and friends. Normative influences were found to exert a moderate impact upon the decision making of participants at all Key Stages, albeit at different levels of influence and for different reasons depending on the age of the participant. Parents and carers were found to have the biggest normative influences, with the normative influence of friends being lesser at all Key Stages, according to interview participants, although secondary school students were more likely to agree on the Likert items that they would do post-compulsory mathematics if they thought their friends might too. However when given a free choice, Key Stage Four participants cited that their parents were more influential than their friends.

The normative impact of parents upon motivations in students is relatively well documented in the literature. It is implied that parents have a fairly low normative impact on mathematics education decision making with a perception that parents wanted young people to 'be happy' (Hernandez-Martinez et al, 2008) and students actively downplaying the role that their parents have upon their post-compulsory decision making (Mendick, 2007). Epstein et al (2010) relate high-mathematical self-concept to encouragement from parents. There is a possibility that parents exert an impact of which they are not aware on students, by encouraging them actively to have high aspirations and to try hard at mathematics (PISA, 2013). Students across all samples reported that they felt encouraged by their parents to do their best. In common with the participants in Brown's (2007) study, participants across all Key Stages but particularly at Key Stage Four also discussed that they at least in part valued input from older siblings as they perceived that they had experience of school and could provide some insights. However, the samples in all of the above mentioned studies were from older students such as undergraduates for the first two studies, and fourteen year olds for PISA. It was not possible to find literature on the normative influences upon younger students at the point of writing this study, so this is a potential contribution to the current knowledge.

Teachers also had a large impact upon the decision to study mathematics at all Key Stages. At Key Stage Four students responded with a median Likert item of a four to the question 'I would study post-compulsory mathematics if my teacher thought I should'. There was a moderate correlation between the intention to study mathematics and the perception of Key Stage Two students that they would if their teacher thought that they should, and 9 of 22 interview participants at Key Stage One valued the opinion of their teacher for this particular decision.

This particular finding has applications beyond the particular motivation in mathematics education specific focus of this study. The relative normative influences are a key part of the more general Theory of Planned Behaviour (Azjen, 1991). It is possibly true that some of the findings here could be used to predict students' behaviour in other aspects of their lives in decision making in other aspects of education. Because of the reasons given by students, perhaps the influence on them of teachers to study any subject is the largest normative influence because of the perception of teachers as experts, and perhaps more general well-being decisions are more impacted upon by parents because of the perception that 'parents want the best for me.

7.2.4 Impact of self-efficacy upon the decision to study mathematics

Across all of the participants in the Key Stages Two, Three and Four samples students were inclined to report a relatively high mathematical self-concept. However there did seem to be some distinction between participants believing that they were good at mathematics and the perception that they were good enough to do it in post-compulsory education. This is a position which would appear to be supported by the literature.

The DfE (2010) found that prior high attainment was a strong indicator as to whether a student would choose to study A-Lvel Mathematics, with students with A/A* (because this study took place before the most recent curriculum change, the students in this study will be awarded grades based upon a numerical system with 1 being the lowest possible grade, 4 being the minimum grade acceptable to enter sixth-form college to study any subject without re-sitting GCSE mathematics, and grade 9 being the highest possible grade) being 88 times more likely to enter A-Level mathematics than a student who attained a lower grade. Brown et al (2003) agree, with participants in their study being told by teachers that A-Level mathematics was not worth attempting if they only attained a B grade. The median Likert score amongst students in Years 4, 5 and 6 in this study was a 3, which is perhaps more indicative that they did not know whether they were good enough at mathematics to study it at college, rather than they definitely thought that they were not capable enough. However, once students reached Year 11 the median Likert score became a 4 for both questions and students were significantly less likely to agree that they would study post-compulsory mathematics, implying that the DfE (2010) and Brown et al (2007) are probably correct. Students make decisions about whether they are good enough to study mathematics, and as per the perceived behavioural control element of the TPB (Azjen, 1991) choose not to study it because they perceive that they probably can't emit this particular behaviour successfully. This would appear to be supported by the research presented by Preiss-Goben and Hyde (2016), who found that a positive perceived self-concept that was sustained through secondary education was the most important indicator of whether a student might choose to pursue the study mathematics once they were no longer compelled to do so.

This particular aspect of the research has meaning beyond motivation to study post-compulsory mathematics. It is noted in the literature that a positive mathematical self-concept is not only important for motivation and enjoyment, but also shares a relationship with success in mathematics (Schukajlow et al, 2017).

7.2.5 Do the attitudes of school students towards mathematics differ at different ages, and if so, how?

7.2.5.1 Enjoyment of mathematics and enjoyment of school in general

Evident in the comparison of the possible intentions to study mathematics when they no longer needed to was that there was a considerable decline in this intention as students became older. It was also evident that there was a decline in the enjoyment in which students took in school in general, though this was of a moderate statistical significance. Their enjoyment of mathematics also declined, but the decline was no worse than that of their enjoyment of school in general. This is agreed to an extent in the literature, where research suggests that attitudes towards school become more negative between the primary and secondary phases (McLeod, 1994).

7.2.5.2 Changing nature of normative influences over time

In this section, the nature of normative influences upon decision making are considered. This part of the methodology and theory is reusable in more general contexts, although here it has been used to measure and analyse the influence of the normative agents on the specific decision to study post-compulsory mathematics. The evidence presented here that normative influences changed could apply to other aspects of decision making by students, for example perhaps when choosing educational establishments. As discussed earlier in the thesis, the subjective norm is the impact of other people on decision making, in this instance the decision to study mathematics when participants no longer need to. Ruffell et al (1998) found that teachers were dominant upon attitudes towards mathematics. Evidence from Ofqual (2017) would appear to be in agreement. In their study, they surveyed both students and teacher and found that teachers exerted an impact upon decision making, and were likely to make recommendations to students based upon what they knew of the student, their capabilities and what they might enjoy. As noted in the literature review we cannot tell explicitly from the studies of the older children when they began to notice and internalise their subjective norms, or whether the younger children had any at all. Prior to this study it was somewhat unclear at what age opinions and attitudes of parents, teachers and friends might begin to affect children's perceptions of mathematics, or whether their subjective norms change or develop during the course of their education. Whilst friends had a relatively low impact on decision making at all Key Stages, parents and teachers had a more significant impact. The reasons given by interview students appeared to change over time to a greater impact of teachers based upon the wisdom that participants perceived that teachers should have.

At Key Stage One, parents and teachers had almost the same normative impact on participants as each other, with frequencies of 10 and 9 out of 22 respectively. When asked at this stage why teachers parents and teachers exerted an influence upon decision making all the participants concerned perceived that these people had authority over them.

At this stage, participants mostly perceived that they might get into trouble if they were not to do something that a teacher thought that they should do. By the time participants reached Year 6, they began to make mention of their perceived authority of teacher wisdom. The important of this perception of teacher wisdom is discussed in relation to the importance of STEM careers education later in this chapter, along with the important of teacher's own attitudes towards mathematics and its perceived difficulty.

7.2.5.3 Perceptions of the utility of mathematics

Black et al (2009) found that the desire to study post-compulsory mathematics was strongly aligned to future aspirations. This would appear to be the case as is evident from the findings presented here by the data from participants in Key Stages Three and Four, though not necessarily from students in the earlier Key Stages. This change in the dominance of this particular part of the theoretical framework is discussed in significantly more detail about how the perceptions of the utility of mathematics change as participants become older.

At all key stages, students were likely to agree that mathematics was important. Forty-five of fifty-six students at Key Stage Two agreed that mathematics was important of very important along with fifty-five of the ninety-five Key Stage Three and Four students agreeing in their long answers that mathematics was important or very important. However, the reasons why changed over time. Perceived every day uses (for example the use of money in shops) remained fairly static whilst the content grew larger as students became older, meaning that students at Year 11 were the most likely to say at interview that some of the content that they were taught they perceived to be useless. At all Key Stages, participants who said that mathematics was likely to be useful for their chosen careers were able to make some reasoned suggestions as to why. However, as students became older they became more inclined to suggest that mathematics would not be useful for their careers.

7.2.5.4 Expanding interests over time

As presented in the ‘Do the attitudes of school students towards mathematics differ at different ages, and if so, how?’ section of the findings chapter, the intention that students express to study mathematics when they no longer have to declines steeply between the time that they are in Year 2 and the time that they reach the end of Year 11, with Year 11 students significantly less likely to report that they would study mathematics when they no longer had to.

This is potentially attributable to a growing sense of self and what participants felt that as a result of this they would like to do with their futures. Whilst participants at Key Stage One were the most likely to agree that mathematics might be useful for their potential careers, students in Year 11 were more likely to agree that they didn’t know whether mathematics would one day be useful to them. The OECD (2013) propose that this is due to general development where the students’ own interests become more diverse, and therefore mathematics becomes less important to them as a whole. This is a little more difficult to find support for in the literature due to the relative ages of students that have been surveyed. Whilst the body of literature is relatively large in this dimension for participants who are at university and in sixth-form, there appears to be a relative dearth of knowledge pertaining specifically to the understanding of utility of mathematics for future careers for younger children.

7.6 Are attitudes towards mathematics fixed or can they change?

As can be seen from the data and analysis presented in the findings chapters, attitudes are certainly not fixed and can change dramatically over time. They change depending upon the experiences of students, both significant like taking high stakes examinations or getting a new teacher, or seemingly insignificant like not getting enough sleep. This is supported by Bandura's self-efficacy theory (1991) which suggests that repeated failure can lead to a lower self-concept. By the same reasoning, this student has grown his self-concept based upon prior successes. This would appear to align with the assertion that the attitudes of young students towards mathematics are fairly mercurial (Ruffell et at, 1998).

7.7 Which of the components of attitude is most dominant upon decision making?

The final research question sought to discover which was the most dominant attitude on the decision to study post-compulsory mathematics. As is evident in the second findings chapter, the answer to this as per the first research question is that just as attitudes change over time, so too do the dominance of each of these attitudes.

As discussed in the Theoretical Framework, The Theory of Cognitive Integration suggests that we perform 'cognitive algebra' whenever new pieces of information are absorbed (Hogg and Vaughan, 2011). As seen in the findings chapters, the weightings of the most dominant components of attitude upon decision making were different at each Key Stage. At the time of writing, there is no other research of which the researcher is aware that makes comparison of the relative weightings of various components of attitude towards mathematics upon decision making. At Key Stage One the normative influences of teachers, feelings of happiness and a perception that they were good at numeracy all seemed to correlate positively with the intention to study mathematics in the same proportions. Students who wanted to study post-compulsory mathematics agreed in fewer numbers that mathematics would be important for their chosen job one day. At Key Stage Two the strongest correlation agreeing that a participant would study post-compulsory mathematics was a belief that they would do so if their teacher thought that they should, a position that was agreed by interview participants who generally cited teacher wisdom as the reason why. The correlation between a belief that mathematics would be useful for their chosen careers and the intention to study post-compulsory mathematics was relatively weak, whilst a positive self-concept, feelings of enjoyment and finding fun in mathematics lessons were all also fairly strong indicators that a participant would agree that they would study post-compulsory mathematics. However, by the time participants had reached Year 11, the component with the most overwhelming dominance was a belief that mathematics would be useful for their chosen careers. This is potentially explicable with the Theory of Cognitive Integration. By the time students have reached Year 11 they are making decisions about their careers which aren't hypothetical. The variable of 'Utility of Mathematics' has become greater for them, so their cognitive algebra has changed. Normative influences had changed, and they became more likely to report a smaller influence of these, because their own futures had become more important to them than what their parents or teachers thought. Interview participants did not report perceived parental authority in the same proportions as participants at Key Stages One or Two. Their cognitive processes had become different, now perceiving their own wishes for their long-term futures to be more important than the probably short term impact of the wishes of their parents.

7.8 Original contributions of this study

There are a number of ways in which this study has addressed the gaps identified in the literature review. In this section I explore how the study has contributed methodologically to the current knowledge of how attitudes of learners in England change over time as well as lending new knowledge to the current base on the attitudes of learners towards mathematics in the dimensions identified in the theoretical framework.

7.9 Empirical contribution of this study

As discussed in the literature review, a number of studies on each individual cross section of this study, or year groups in those cross sections exist but no overarching study which applies the same methodology to all has yet to be conducted and written. All of the studies discussed in the literature review examined different definitions of attitude, or used different instruments. Because most of these studies examined the attitude of students at different points in their mathematical educations, except for one conducted outside of England, it was difficult to tell from the reading at what point attitudes of learners in England change specifically, and whether these changes in attitude might lead to their ultimate decision not to study post-compulsory mathematics. This is the largest empirical contribution made by this study. It is possible to begin to understand how attitudes to mathematics (and potentially by extension attitudes to other curriculum subjects) are built over time, and to understand what the significant influential factors are upon decision making as students grow older.

A major contribution to knowledge of this particular thesis collection of data regarding specific attitudes to mathematics of students in Key Stage One. Whilst a small number of studies exist (Borthwick 2011, West et al 1997 and Rufell 1998), these are harder to find at the time of writing than research pertaining to older students. West et al (1997) focus on 'like and dislike' whilst Borthwick (2011) provides some insight as to whether students were happy or unhappy in mathematics lessons This study contributes empirically to the knowledge base of attitude to mathematics of students of mathematics in England aged seven years old by expressing specifically in their own words how they perceive mathematics in terms of its day to day uses, how they perceive that they might use it in their futures and how it makes them feel. Whilst other studies make comparative use of cross-sections to gather empirical data on attitudes towards mathematics and Science subjects, for example the ASPIRE (Archer et al., 2013) project, they do not have the same range of cross-sections which enables comparison across all Key Stages. The students in the ASPIREs sample however were aged 11-14, and as can be seen by the data presented here students begin to form perceptions of their school subjects much earlier, as is evident from the data collected from students in Key Stage One.

The evidence presented here also provides comparison of the weightings of influence upon decision making. Whilst the studies presented in the literature review provide insight into the attitudes of mathematics of students at different ages, they provide insight into individual factors such as mathematics anxiety (Dowker, 2012), or whether students perceive themselves to be a 'maths person' (Mendick et al, 2007, Black et al, 2009). The work of Brown et al (2007) provides specific insights into the reasons of individual participants as to why they have decided that they will no longer continue with post-compulsory mathematics studies, but does not provide any ranking as to the importance of these factors to students when they make their decision. The evidence presented here demonstrates that the importance of individual influences upon students change over time, but also the most important factors to students upon their decision making at the time that they need to choose their post-compulsory options. This might potentially provide insight as to the priority in which these could be tackled by teachers, parents and other interested parties if participation in post-compulsory mathematics (and potentially other STEM subjects) is to be increased.

Because of the nature of the free-choice long answer questions and the use of the collection of data by interview, unexpected insights emerged. One of these was the impact of the nature of mathematics instruction received by learners at different stages in their educations in England. Again, whilst other studies provided insight into how students feel about some of the ways in which the taught content makes them feel, for example that it's 'dull' (Royal Society, 2008), students in this study provided specific concrete examples of the content with which they struggled and the content which made them feel good, the specific type of instruction which they did not enjoy (for example students in Key Stage Four who felt that they nature of their taught mathematics content was repetitive). From the evidence presented here it is possible to know that students at Key Stage Two spoke enthusiastically of the practical application of their taught content in their project work, but that at Key Stage Four students did not express any more practical uses of the concepts that they were learning in their mathematics lessons, and that they reported that they simply could not see the point in learning any more mathematics.

7.10 Methodological contribution of this study

This thesis builds upon the current knowledge in its utility of a monodimensional set of comparable data collection methods utilised across all participants from all key stages. Prior to its publication, no one study existed that made direct comparison possible across such a broad cross-section of participants, therefore making it possible to begin to identify the points at which students become more influenced by their own intrinsic motivations (such as their career choices) than those which are external (such as the influences of their teachers and parents).

One of the largest contributions that this study makes methodologically is that it utilises a cross-sectional methodology using stratified sampling to capture the changing dispositions towards studying mathematics at school of students across key stages. Prior to this, there were a number of other studies into motivation in mathematics, but these used different cross-sections of students, for example Ruffell (1998) also uses cross-sections to understand attitude towards mathematics (though not specifically linked to motivation as is the case of this thesis), but these are limited to Year 6 students, undergraduates and trainee teachers. The study is also different in its execution of data collection, because although the researchers gathered data from participants over time, they gathered data from the same participants just weeks apart. The study presented here paints a picture of the experiences of students over the course of their entire mathematics educations.

Additionally, this study presents an explicit analysis of attitudes and dispositions correlated directly with the intention to study or not to study post-compulsory mathematics. Again, a number of studies examine emotions and perceptions of mathematics, for example Borthwick (2011) similarly to this study examines the emotions and perceptions to students, but these are not tied to the explicit study of what the impact of these upon students might ultimately be in terms of their desire to keep studying mathematics when they no longer have to. Comparable with the ASPIREs project was the UPMAP project (Mujtaba and Reiss, 2014; Mujtaba, Reiss and Hodgson 2014). The UPMAP project was similar in its aspiration to relate attitude directly to mathematics and science post-16 uptake. The sample for this study was very large, with 23000 participants in the initial data collection and follow up data collections from around 7000 participants two years later. Data collections were also conducted with undergraduates. However, since this very significant study was conducted with older participants, its use in identifying at which point attitudes towards mathematics being to crystallise is limited. The findings of this study supported by significant theories of attitude suggest that humans form attitudes all the time because new experiences will build upon previous experiences (Raved and Assaraf, 2010). As can be seen from data collection with the young children in this study this change is constant, even in much younger participants.

The methodology used for this research provided a useful vehicle for answering the research questions. Since the thesis needed to be produced within a time-limited frame, a cross-sectional design was the most appropriate. The utilisation of a longitudinal study was proven to be inappropriate; there were simply not enough years with the time-scale necessary to produce a PhD, but as seen in the findings chapter the cross-sectional method did give insight into how students felt at different stages in their mathematics education. Because there was no major passage of time between data collections at each of the key stages, as there would have been in a longitudinal study, this research was not sensitive to attrition (Menard 1992). An additional advantage was that the burden of having to participate in a number of data collections was not placed upon participants, making the study less onerous for them and therefore more ethical. The online questionnaire made possible a data collection that could be completed at the convenience of the participants, and made quantitative analysis possible. The use of the Likert items allowed for direct comparison between participants in Key Stages Two, Three and Four further assisting in answering the research question ‘How to attitudes towards mathematics change over time’. The numbers of responses were good, and no problems were reported by participants or teachers at the research sites concerning any understanding of the Likert scales or reading the questions. This would appear to suggest as per van Laerhoven et al, 2004, that the low cognitive load necessary for answering these kinds of questions makes them suitable for use with children. Whilst there was much qualitative data that was gathered from the long answer questions, the addition of the interviews creating a multiple-methods approach allowed for greater depth of understanding, and allowed the interviewer to reframe the questions when participants didn’t understand. Additionally, students chose to bring their books with them to the interviews unprompted which had the unexpected benefit of starting a discussion surrounding what they were being taught and how. In turn this provided some reasons for changes in enjoyment and motivation between students in terms of the styles of teaching and breadth and depth of content that they were learning. This is discussed in more detail later in this chapter.

By comparing median Likert scores questions analysis of the influence that each of the components of attitude have upon the intention to study, or not study post-compulsory mathematics became possible, which meant that this study also makes the original contribution of analysing the dominance of these components and in turn of comparing the relative influences of these upon decision making. Whilst a number of studies exist which analyse the impact of attitude upon motivation (Archer et al, 2013) and some exist which examine attitude towards mathematics in general (Ruffell, 1998, Black et al 2009) these don't compare the relative influence of different components of attitude upon motivation. In the sections that follow, the specific empirical findings are discussed in relation to the current literature, and conclusions drawn as to the specific gaps in the knowledge that this study contributes to filling.

7.11 Theoretical contribution of this study

This research makes an original theoretical contribution in its use of a hybrid framework utilising The Theory of Planned Behaviour and Di Martino and Zan's defined elements of attitude towards mathematics. It is unique in its breaking down of the component parts of attitude, and its specific examination of how these impact specifically upon post-16 decisions. The ASPIREs (Archer et al, 2013) project aimed to gather similar data on students' motivations to study Sciences. As well as its use of a smaller cross-section of students, the ASPIREs project was significantly different in its theory. The theory adopted for that particular study was largely sociological and made use of Bourdieu's cultural capital, which has been discussed in the theory of this thesis though not used. There were some similarities in that ASPIREs identified a range of components of attitude such as self-concept, but also used a number of non-attitudinal components such as parental perceptions of Science.

Whilst the framework presented here has been applied specifically to mathematics education and choices and has only been used here to look at attitudes and their impact upon post-compulsory decision making here in England specifically, this framework would be transferrable to motivations in any subject and is also applicable to data collection in this area outside of schools in England. The components chosen for the theoretical framework such as normative influences, affective components, self-efficacy (referred to in this thesis as self-concept), vision of a subject (both how the participant perceives it in general), and the possibility of success in performing an action were certainly useful in providing a lens for data collection and analysis in the context of this study but are neither subject nor country specific, and for this reason would be useful in gathering and analysing data surrounding any academic subject in any country.

The other unique theoretical contribution of this research is that one single definition of attitude used to inform data collection across all key stages. Because the age range for data collection in this project was large, comparison with other studies became difficult because of the smaller ranges of ages when compared to the data collection and analysis presented here. As a result, in order to write the literature review presented towards the beginning of this thesis it was necessary to compare a number of studies to begin to understand the knowledge base for the entire age range of interest. With the number of studies needed to make a comparison of the current knowledge of how students' attitudes towards mathematics change over time came the accompanying number of different definitions of attitude. West et al (1997) used a generalised definition of 'like and dislike' and Bothwick (2011) gathered emotional responses and participants' perceptions of peers (which indeed was used in this study to inform the Likert item 'Lots of people in my class are better at mathematics than me'). In this study, the definition of attitude from Di Martino and Zan (2009) was used to inform the data collection across all of the samples, therefore providing direct comparison of attitudes between the time that students are seven years old and the time that they are sixteen. This method of making a hybrid theoretical framework using Azjen's Theory of planned behaviour (1991) could be possible with attitudes towards any action, as long as a reliable definition of attitude was found to align with Azjen's components of perceived behavioural control, normative influences and behavioural beliefs x outcomes.

7.12 Summary

In this chapter, the original contributions of this research have been considered. They have been explored empirically, methodologically and the original contribution to theory has been discussed. In the Conclusions chapter which follows the implications of the findings of this research are considered for both policy and practice both globally and in the context of mathematics education in England. Directions for future research are considered, and final conclusions drawn.

Chapter 8- Conclusions

The wider implications of the findings presented in the Findings and Discussion chapters are considered in the wider context of mathematics education in England and recommendations made for how the research presented here could potentially impact upon policy. Recommendations for future research are also made.

8.1 The limitations of this study

Because of the relative ages of participants in this study, a direct comparison of the factors of attitude was not possible using the same instruments. Whilst data was gathered successfully from participants in Key Stages Two, Three and Four and subsequently analysed quantitatively, only qualitative data was gathered from the youngest participants and therefore analysis of the data was largely qualitative.

It would perhaps be advantageous in any future studies in this area to ask participants to rank the components of attitude by impact upon their post-16 decision making. This would be possible perhaps across all Key Stages, and allow for further direct comparison between the factors, and would make the dominance of factors according to the participants explicit.

Because of the nature of recruiting participants in a school setting, capturing a representative sample was not without difficulty. The relative numbers of boys and girls participating in the Year 4 questionnaire sample was problematic, with only a third of respondents being male. Whilst the focus of this research was not impact of gender upon decision making, it is well documented (Mujtaba et al, 2010, Jones, 2008, Brown et al, 2008, Dowker et al, 2012) that gender is impactful upon post-compulsory mathematics participation.

This study could have been further strengthened by the use of secondary data from schools to ascertain the relative prior attainment of students. Whilst schools and teachers were instructed that a mixed-attaining sample was required, secondary data was not used to ensure that this had happened.

In order to ensure that this study was conducted ethically, all participants were required to return permission slips indicating that both they and their parents or guardians consented to their participation in the study. In spite of reminder steps discussed in the methodology, the numbers who participated were relatively small in comparison with the size of the entire year group. The sample size at Key Stage Four was particularly limited, and a larger sample size would have been desirable. Whilst 44 Year 7 students participated in the online questionnaire, only 29 Year 9 students participated and 22 from Year 11. It is possible that the findings may have been different if the entire cohort had participated. For this reason, the final numbers of participants could be considered to be a limitation of this study, and caution should be applied in asserting generalizability of the quantitative Key Stage Four data.

8.3 Implications for policy and practice

The findings of the research presented in this thesis arguably have some practical applications for policy and classroom practice in the teaching of mathematics, and possible in the teaching of other subjects. These findings are discussed in relation to the current literature in the sections which follow.

8.3.1 Does the current approach to teaching the increased content of Mathematics at Key Stage Four impact upon the decision of learners to study post-compulsory mathematics?

As part of the interviews at each Key Stage, students were asked to discuss what they were learning, particularly in instances where they asserted that mathematics was sometimes easy, and sometimes difficult. Participants suggested a number of topics which they found difficult which are discussed in further depth in the sections above.

In addition to the points discussed in the above section, there is some further support from the evidence collected here for the argument that students should be told explicitly what the practical, real world applications of what they are learning in lessons might be. There were limited examples in the literature as to what young children's perceptions of the utility of mathematics might be, which is a gap in the knowledge that the findings presented in this thesis go some way towards filling. The existing literature (Ashby, 2009) suggested that the utility perceived by students was limited to counting money when shopping, which is a position echoed by some of the findings from this thesis. Again this is directly comparable with answers given by students in Key Stage One. Students at this age were slightly more inclined to say that they used mathematics for homework or counting money. When asked what adults used mathematics for, they also replied that they thought adults used mathematics for shopping or for doing homework with their children.

On the surface, this very narrow view of the practical utilities of mathematics might not be a problem. However, they are restricted to operations learnt at Key Stage One, whilst the content taught becomes significantly larger. This is particularly problematic when it is contrasted with some of the views presented by students in Key Stages Three and Four that much of the mathematics that they are taught is 'useless'. This student experience is evident in some of the existing literature, for example one student in the UPMAP (2010) survey reported that 'The amount of insignificant maths work is quite big'. The survey also found that whilst students perhaps dropped pure mathematics, some chose instead to study more practical mathematics based subjects like economics. There was some evidence of this in the data collected here, for instance in the case of the Year 11 student who had chosen to study a vocational accounting certificate rather than mathematics A-Level. This perception is likely to have an impact on motivation to study mathematics, which is a position noted by Black et al 2009, who found in their case study approach that a sixth form student reported that mathematics was largely irrelevant to his everyday life, saying in interview that he was ‘not interested in the price of coffee’. The National Audit Office agrees, with only half of Key Stage Four and Five students in their large scale survey perceiving any practical utility in mathematics.

Green (2002) suggests that in order to promote the value of a task, teachers should explain the reason for it and emphasize its importance and usefulness. It would perhaps therefore be advantageous to the promotion of the further study of mathematics for teachers to provide some practical, real world contexts in which the topics being taught might be useful. This limited instrumental vision of mathematics has implications beyond the effects upon motivation examined in this thesis. When this is considered alongside reading from the literature review, this issue is evidently more wide reaching (Black et al, 2009, Epstein et al, 2010). There are concerns that a low instrumental vision of mathematics (described in this thesis in terms of the exchange value), might lead to lower performance (OECD, 2013). As explored in the sections which follow, a lower performance will eventually lead to lower mathematical self-concept, and perhaps mathematics anxiety. UPMAP (2010) also suggests that it is likely to be lower attaining students who are more likely to feel aggrieved at the perceived uselessness of what they are being taught during their mathematics lessons. It is perhaps important then to give consideration to the teaching of mathematics at Key Stage Four. The new curriculum has provided some opportunities for students to be examined on applied mathematics, and has a larger problem solving component. Banet and Nunez (1997) suggest that it is important for students to have a chance to apply skills learnt to real world problems in order to consolidate learning, it would also perhaps be advantageous to make explicit when teaching secondary school mathematics the areas of real life in which the specific mathematics skills being taught might be applicable. It is important to consider the findings of this thesis not only in the dimensions of each of the components of attitude individually, but rather the impact of these as a whole if the research presented here is to have any practical application.

8.3.2 Motivation and the current style of examination

When attending interviews, students discussed what they were taught and how. There was also evidence of this in the long answer questions in the online questionnaire. There has been some exploration into this in the existing literature, though none that makes direct comparisons of the new course content at all the Key Stages at the time of writing this thesis. Again, there was no overarching study comparing teaching methods at each Key Stage and aligning them with motivation; though this was an unintended consequence of this study. Boaler (1997) discussed mathematics and motivation with Secondary School students, though some of these did reflect upon the nature of instruction over the course of their education and how this impacted upon their motivation. Martinez-Sierra and Garcia Gonzalez (2017) also not that students do not feel that mathematics is intrinsically boring, bu that this perception depends on the instructional style of the teacher.

As discussed in the findings chapter at Key Stage One, students were learning small mathematical operations which were applied to real world scenarios. They participated in activities such as colouring parts of shapes in order to understand what fractions might look like pictorially. They had recently taken part in SATs examinations which were highly individualised. In years 4 and 6, the discrete mathematics that had been taught in specific mathematics lessons had been contextualised into projects; these involved some group work, school trips, imaginative applications of number as well as some activities where students were encouraged to think about how mathematics might be applicable in the work place, for example by calculating profit and loss as a part of a theme park project. In general, interview participants reported enjoying these projects and were keen to show how they had applied their mathematics skills and how they understood the links between the project and what they had learnt in their mathematics lessons.

By contrast, when students reached Key Stages Three and Four they made no mention at all of any group or project work in their mathematics lessons. This perhaps could also be related to their lack of understanding of how the content taught could be useful in the workplace or during adult day-to-day lives. Students at Key Stage Three and four were more likely to describe mathematics as ‘repetitive’ and ‘boring’.

This view of mathematics aligns with that of the evidence presented both by Brown (2007) and The Royal Society (2008), which is that mathematics at secondary school is over-individualised with a reliance on repetition. This was echoed by some students at Key Stage Three who said that they were repeating mathematics learnt at Key Stage Two, though this didn’t necessarily mean that they reported lower levels of enjoyment in mathematics. At Key Stage Three, arguably this repetition is necessary as students arrive from different feeder schools that may have covered content differently.

Students at Key Stage Two reported higher levels of enjoyment in mathematics than those in Key Stages Three and Four, which can perhaps be attributed to the varying style of instruction, a position which would appear to be corroborated by Boaler (1997). This would appear to further support the assertion made by the Royal Society (2008) that students are put off the further study of mathematics as they find it to be repetitive and over individualised.

They also made significantly more references to summative assessments, whilst students at Key Stage Two were more inclined to show formative marking in their books.

8.3.4 Is the current approach to increasing numbers of students studying STEM subjects the most effective?

Since part of the problem that this research aims to solve is the perceived low uptake of STEM subjects at A-Level, university and for careers, it is important to consider whether the current approach to increasing take up is likely to be effective given the findings of this thesis.

ASPIREs and UPMAP both suggest that embedding some STEM careers education into the teaching of these subjects at school might lead to higher take-up of post-compulsory STEM subjects. Given the relatively low impact of normative influences upon decision making, would teachers providing careers advice on STEM subjects have the desired impact? According to the findings presented in this thesis, the answer to this question is potentially 'yes'. Students perceived that teacher had the knowledge to advise them on which subjects to take, so it follows logically that they would probably have the same perception about careers in the subjects in which they perceived teachers to be the experts. A close second normative influence was that of parents, who they perceived knew them best and had their best interests at heart. What is unclear from this study is what the impact might be of external careers advice from relevant industries. Given that the students had fairly profound reasons for trusting their parents and teachers, the impact of people who are unknown to them might be fairly minimal. Reiss and Mujtaba (2017) argue that whilst such interventions might broaden students' world-views, their careers aspirations are probably fairly resistant to change. What is arguable though is that because of the strong perception that a lot of the mathematics taught particularly at Key Stage Four is 'useless', perhaps teaching more of the day-to-day uses relevant to these age groups might increase motivation, and therefore increase enjoyment and therefore increase the desire to one day study post-compulsory mathematics.

As a caveat to the above, whilst the single biggest normative influence in this study was that of teachers, it is important to consider that given the potential views of difficulty of mathematics amongst teachers (Ofqual, 2017) and the accountability measures for schools currently in place for A-Level achievement, whether teachers would be likely to recommend A-Level mathematics as a future course of study for students. This is reinforced by other literature, for example Brown et at (2007) suggest that students use this perception and advice from teachers almost as an excuse for not pursuing post-compulsory mathematics. Ofqual (2017) suggest that teachers are performing their own cognitive algebra when making these kinds of recommendations to students. Teachers base their decisions upon the knowledge of their students e.g. their capabilities and their likes and dislikes, their own views of how difficult subjects are and their own performance measures. This could potentially mean that a teacher who might teach a current GCSE student in their A-Level years advise them to study post-compulsory mathematics if they thought that their performance data as teachers might be negatively impacted? Whilst potentially little can be done to convince teachers to do something that might cost them their job or position in an institution such as recommending that a student who might negatively impact their professional standing by studying post-compulsory mathematics does so, it might be worth providing all teachers with more information about A-Levels and other post-16 routes, since perhaps students might ask teachers other than those who teach them mathematics. This increased knowledge might lead teachers to give better quality advice which is less impacted by their own perceptions of mathematics and its attendant difficulties.

8.3.5 The practice of setting and impact upon mathematical self-concept

In schools in England, the practice of 'setting' students by 'ability is common (Taylor et al, 2016). Ability in this instance means 'prior attainment'. The most common reason cited by for this practice is that it enables teachers to challenge the most highly attaining whilst supporting those who are struggling (DfE, 2005) It has been fairly robustly challenged as making little or' no difference to students' attainment, and indeed students in England have directly reported that they feel unhappy when placed in lower sets or bands (Boaler, Wilam and Brown, 2000). Whilst this study claims no focus upon or answers to the impact of setting and ability grouping upon the later decision to study post-compulsory mathematics, it perhaps important to note that a number of interview participants from across all Key Stages in the study mentioned ability grouping, therefore showing an awareness of it and making a connection between mathematics and this practice. Whilst there were no participants who commented that their table made them unhappy, it is perhaps possible in light of the findings from Boaler, Wilam and Brown (2000) that students might use this practice to inform their negative self-efficacy.

8.3.6 Implications for the theory and research design beyond the context of this study

In the section which follows, some of the unintended findings from the research presented here are explored, and the potential implications for policy and practice are considered.

8.3.7 The formation of self-concept and the impact of teacher feedback

One of the unexpected insights that this thesis provided was some different ideas as to how students use teacher feedback to form their self-concept, and the impact that this has upon their decision making. Most of the students surveyed across all Key Stages thought that that they were good at mathematics, and when interviewed to provide further detail as to why they thought this, students reaffirmed that they were doing well in mathematics. When asked why they thought that this was, they replied that they knew they were doing well because of feedback from their teachers.

Across all Key Stages, interview participants cited that even if they weren't intending to study post-compulsory mathematics they might if their teachers encouraged them to do so because they considered their teachers to be the absolute experts in how they were performing in mathematics. For this reason, it is worth considering that feedback and praise should be given to students in order for them to develop a positive self-concept. This position would appear to be supported by Bandura's (1982) position that verbal praise can lead to a perception of higher self-efficacy if the praise is within realistic bounds. Arguably, the inverse of this is true. A series of repeated failures would appear to lead to diminished self-concept (Bandura, 1997).

This is also evident in some of the literature reviewed, for example Dowker (2012), asserts that repeated failure in mathematics contributed to higher incidences of mathematics anxiety in her younger participants. She argues that much like Alice, once there have been an number of successive failures students are likely to believe that they can never catch up. This has implications beyond motivation to study post-compulsory mathematics and into performance. Bandura (1997) and OECD (2013) both argue that higher self-efficacy leads to higher performance. The DfE (2010) found similar results, asserting that the most important factors in both mathematics and science uptake and achievement were not only enjoyment of the subject and working hard at school, but a belief in one's capacity with the subject. It is important then to consider carefully the impact and value of feedback and its delivery because of the evidently significant impact upon motivation and decision making. Rakoczy et al (2013) also argue that written feedback is an important aspect of a supportive classroom climate, and shows a positive impact upon students' motivation. In contrast, Van Der Beek et al (2017) suggest that a student's perception of their own ability might be more important in relation to their self-concept than the marks they achieve in assessed work. This findings presented in the findings chapter in this study would not appear to support this. Students across the Key Stages made reference in interviews to using teacher feedback to inform their perceptions of whether they were doing well in mathematics.

8.4 Recommendations for future research

Whilst the impacts of all of the factors in the theoretical framework have been rigorously examined, there are arguably more questions that need to be answered following this study.

There is demonstrable change in attitude towards mathematics over time. Whilst this is perhaps a more noticeable change, it appears to marry with a more general lack of enjoyment of school overall. This is perhaps an avenue for future exploration. I would suggest that following this research, perhaps comparing the findings with how children and young people develop and form their attitudes to other aspects of their lives might give wider context to this study. I would also suggest that whilst some exploration of attitudes of participants towards other subjects was conducted in the course of this study, some further exploration of their attitudes towards other curriculum areas might lend further context to some of these findings.

This study was conducted during a time of mass curriculum change across all of the Key Stages. In particular, a 'content rich' curriculum was implemented at Key Stage Four. This might perhaps mean that the gap between Key Stages One and Two and Three and Four might be bigger for these participants than for those in future cohorts. Perhaps one day those students in Key Stages Three and Four might feel better prepared for the pressures of the terminal Year 11 examinations than those who have come before them as a result of a supposedly more rigorous experience of mathematics during the earlier years of their education.

Additionally, whilst this study provides some insight into how attitudes develop towards mathematics over the course of students' Infant, Junior and Secondary Educations, some further work could be into attrition during their A-Levels. Whilst this study provides insight into the development of attitude whilst participants are studying mathematics as a compulsory subject with significant support, it does not examine what happens once they have made perhaps the biggest leap in depth and difficulty of subject knowledge, and are perhaps in an environment where support is more minimal and they are no longer compelled to rise to the challenge.

As can be seen in the findings chapters, participants of all ages were inclined to say that mathematics is 'sometimes easy and sometimes difficult'. Across the Key Stages, interview participants universally agreed that this was dependent upon task content. Perhaps further exploration of which particular tasks students struggle with, or might be inclined to enjoy less than others might be worthwhile. Schukajlow et al (2017) agree that this is a direction that requires future research following their survey of mathematics motivation research in the last ten years.

8.5 Final thoughts

This study has provided some evidence to suggest how the attitudes of participants change over time, and how children and young people prioritise these factors when making decisions about their educations. It is perhaps time to think about a change of policy in our sixth form provision if larger numbers of students are to be inspired to pursue post-compulsory mathematics. As seen earlier in the thesis, students were exposed to pre-testing and catch-up coaching in Key Stages Two, Three and Four. It is only on entrance to Year 12 that students are required to meet a minimum standard of proficiency (Ofqual, 2017), rather than the guaranteed receipt of ‘catch-up’ coaching. Perhaps this change of approach would be worthy of some further exploration.

Also evidenced in this study was a distinct attachment of perceived exchange value to the desire to study post-compulsory mathematics. This was accompanied by a growing perception, particularly by those participants in Key Stage Four that parts of the content of the mathematics curriculum was ‘pointless’. Students at all Key Stages only suggested a limited variety of applications of mathematics outside of school, and the desire to pursue post-compulsory mathematics was largely tied to a perception that it might be useful for a chosen career. Perhaps some further policy change is needed in the development of the ‘content rich’ mathematics curriculum including the further addition of practical applications of number, as well as content designed to foster enjoyment of mathematics.

Appendices

Appedix One – Ethics form

SSEGM ETHICS SUB-COMMITTEE APPLICATION FORM

Please note:

- ***You must not begin your study until ethical approval has been obtained.***
- ***You must complete a risk assessment form prior to commencing your study.***
- ***It is your responsibility to follow the University of Southampton's Ethics Policy and any relevant academic or professional guidelines in the conduct of your study. This includes providing appropriate information sheets and consent forms, and ensuring confidentiality in the storage and use of data.***
- ***It is also your responsibility to provide full and accurate information in completing this form.***

1. Name(s): Claire Walker

2. Current Position Postgraduate (PhD) student at University of Southampton.

3. Contact Details:

Division/School School of Education, University of Southampton.

Email caw1c11@soton.ac.uk

Phone

4. Is the proposed study being conducted as part of an education qualification (e.g., PhD)

Yes, PhD in Mathematics Education

5. If Yes, state name of supervisor

Dr Charis Voutsina.

6. Title of Project:

The factors which affect the decisions of students in England to study mathematics in post-compulsory education: A cross-sectional study

7. What are the proposed start and end dates of the study?

May 2016 until July 2016

8. Describe the rationale, study aims and the relevant research questions

The performance of UK students in International comparison studies has attracted significant media and government attention. Together with an 'undesirably low number of students opting to study mathematics at A-level, there are some concerns about the mathematical abilities of our learners, and of our work force.

In my study, I aim to discover some of the attitudes, and therefore some of the factors which motivate students in England to opt, or not opt to study mathematics in post-compulsory education, and at what age these attitudes begin to develop and why.

Research Questions:

This study aims to answer the following questions:

1) How do Year 7, 9 and 11 secondary school students perceive the value of mathematics?
2) What are the attitudes of Year 7, 9, 11 secondary school students towards mathematics?
3) What are some of the motivating factors which might cause a student to choose to study mathematics at A-Level?
4) How do students in Years 6, 4 and 2 perceive the value of mathematics?
5) What are the attitude of students in Years 6, 4 and 2 towards mathematics?
6) How does the attitude of students in England towards mathematics differ, if at all?

9. Describe the design of the study

<u>Participants in Years 7, 9 and 11</u>

This study will utilize a mixed-methods approach. I have designed a survey which comprises some Likert questions, some Likert-style questions and open questions. I have included the Likert and Likert-style questions to ensure that students give responses that will answer my research questions, and some open questions so that students are able to respond with the factors that are most important to them that might not be covered in my questions. These questionnaires will be completed online using a hyperlink emailed by the school's IT technician to the students' school email accounts. Once I have collated and analysed my responses, I will choose one a random sample of each year group to participate in semi-structured interviews.

<u>Participants in Years 4 and 6</u>

Participants in Year 6 will complete the study as outlined above, with the exception that in the absence of their own school email accounts, students will complete the online survey using a computer on which the online survey has been loaded for them.

Students in Year 4 will complete paper surveys which will be handed to me at the end of the session. They will complete paper surveys since I wish to use a pictorial Likert scale with this age group, and the layout of the iSurvey webpage may not be easy for participants of this age to understand. Selected participants will then take part in audio-recorded semi-structured interviews.

<u>Participants in Year 2</u>

Since the likelihood is that not all of the very youngest participants will have the literacy necessary to complete the questionnaire, they will take part in individual interviews which will be video recorded. During the interview, they will be asked to complete Likert items by pointing to the face which most accurately shows their feelings towards a given statement. They will also be asked some semi-structured questions during these interviews.

10. Who are the participants?

The participants will be Year 7, 9, 11 students at School X (consent email from assistant headteacher attached). I will ask around 200 students in each year group to participate in the questionnaire stage of my study. I will use tutor group sets so that my sample contains a representative sample of all academic attainments. I will then ask a representative sample from each cohort (those who have completed the questionnaire) to participate in face-to-face interviews.

11. If you are using secondary data, from where are you obtaining it?

I will use some secondary destination data which sixth form colleges provide to schools in order to track the progress of last year's Year 11 students once they have left secondary education in order to see how easy it is to track destination data once they have left school. I will then make this part of my main study at a later date.

I will use CATS scores already collected by the college to inform me of the attainment of my participants, and check that the tutor groups contain representative samples of ability ranges.

12. If you are collecting primary data, how will the participants be identified, approached and recruited to the study?

(please attach a copy of the information sheet if you are using one)

The participants will be asked to answer a survey in the form of a questionnaire on their attitudes towards learning mathematics. Students will be asked to participate in their tutor groups because these are comprised of a representative mx of high, mid and low attaining students. I will speak to each tutor group, tell them about the study and provide them with consent forms, participant information forms and parental information letters if they are happy to proceed with participating in my study. I will then select one student from each year group who has indicated in their survey either a definite desire to study mathematics in post-compulsory education, and one who has given a definite indication that this is not their intention, to take part in a semi-structured interview about their feelings and attitudes towards mathematics.

13. Will participants be taking part in the study without their knowledge and consent at the time (e.g. covert observation of people)? If yes, please explain why this is necessary.

No, participants will be fully briefed as to how their data will be collected, stored and used. They will be provided with a participant information sheet, and will be able to decline participation if they choose.

14. If no to 13., how will you obtain the consent of participants?

(Please attach a copy of the consent form if you are using one)

Participants will consent to taking part in my research using the consent forms provided, their parents will also consent to their participation by signing these forms. The headteachers of the participating schools were approached and permission obtained before ERGO approval for this study was sought.

15. Is there any reason to believe participants may not be able to give full informed consent?

If yes, what steps do you propose to take to safeguard their interests?

No.

16. If participants are under the responsibility or care of others (such as parents/carers, teachers or medical staff) what plans do you have to obtain permission to approach the participants to take part in the study?

I have obtained permission from the schools that these children attend, but will need to seek further consent from their parents. I will request that the students complete the study in their tutor groups, and ask their form tutors to administrate it. I will send home a letter to parents explaining what is happening, and ask that sign the attached consent form if they are happy for their children to participate. I will provide copies of the participant information sheets, surveys, interview schedules and permission forms to both the headteacher of the school.

17. Describe what participation in the study will involve for study participants. Please attach copies of any questionnaires and/or interview schedules to be used

Please see attached questionnaire

Participants will need to complete the consent form and return it to me. They will be emailed an isurvey link to the survey, which they can complete on computers in tutor time. If selected following analysis of the surveys, I will contact participants by asking them at school to take part in the face-to-face interview part of my study. These participants will be provided with a new participant information sheet and consent form detailing what they will need to do if they wish to take part in this section of the study. On returning completed participant consent forms, they will take part in a semi-structured interview about 30 minutes long.

18. How will it be made clear to participants that they may withdraw consent

to participate at any time without penalty?

This has been made explicit to the participants in the participant information sheet, and I will also include this as part of the email message which accompanies the survey, participant information sheet and consent form. It is also made explicit on the consent form. This will also be made explicit in the information letter that will be provided to parents of the participants.

19. Detail any possible distress, discomfort, inconvenience or other adverse effects the participants may experience, including after the study, and how this will be dealt with.

I do not anticipate any distress, discomfort, inconvenience or any other adverse effects. The survey should only take around 20 minutes to complete. If the survey is inconvenient, I have made it clear to the participants that they are under no obligation to take part.

The secondary school has given permission for interview participants to complete their interviews during non-core lessons (e.g. Physical Education, Personal Social and Health Education) during lunchtime sessions, so that learning is not interrupted.

20. How will participant anonymity and confidentiality be maintained?

I will not include any information that could be used to identify a participant anywhere in my thesis, and I will store the data securely as outlined below in order to protect the rights of my participants. Survey and interview data will be anonymized in my final write-up.

21. How will data be stored securely during and after the study?

Data will be stored on a password protected computer that will either be in my possession or stored securely at all times. It will be backed up to a removable hard drive that will also be stored securely. Results will be stored securely within the isurvey system. I will store any recordings of interviews on my personal computer, and back them up both securely on line and on a portable hard drive which will be stored securely.

22. Describe any plans you have for feeding back the findings of the study to participants

Students are welcome to read my completed report if they request it from me.

23. What are the main ethical issues raised by your research and how do you intend to manage these?

The main ethical issue here is the age of the participants. I have described how I will collect my data in an appropriate manner which meets the safeguarding requirements of my school. I have taken steps to make sure that parents understand what will happen, and are happy for their children to proceed.

24. Please outline any other information you feel may be relevant to this submission.

Not applicable.

Appendix Two – ERGO Permission email

From: ERGO [ergo@soton.ac.uk]
Sent: 09 May 2016 17:14
To: Walker C.A.
Subject: Your Ethics Submission (Ethics ID:20166) has been reviewed and approved

Submission Number: 20166
Submission Name: The factors which affect the decisions of learners in England to study post-compulsory mathematics: A cross-sectional study
This is email is to let you know your submission was approved by the Ethics Committee.

You can begin your research unless you are still awaiting specific Health and Safety approval (e.g. for a Genetic or Biological Materials Risk Assessment)

Comments
1.Thank you for the changes. Good luck with the study.

Click here to view your submission
Coordinator: Claire Walker

ERGO : Ethics and Research Governance Online
http://www.ergo.soton.ac.uk

DO NOT REPLY TO THIS EMAIL

Appendix Three – Online Questionnaire Key Stage Two

Thank you very much for agreeing to take part in my survey about pupil attitudes towards Mathematics. I hope that you will make the most of this opportunity to share your views and opinions. Your ideas, and those of your classmates will be shared with your maths teachers and headteacher, and with the University of Southampton in my final written report but no-one's name will be shared. I hope to get some clues about how **you** feel about Maths.

Claire Walker

- Please tick the statement in each case that applies most to you
- Please be honest and give examples of your experiences
- Remember, if you don't wish to take part, then you don't have to!
- If you do not wish to answer these questions, please skip the question

About you Name: ______________________________

How old are you? Years: ☐ Months: ☐

School Year: ☐

Are you male or female?

Male ☐ Female ☐

I think I will probably study Maths at college

Yes ☐ No ☐

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
My parents encourage me to do my best in Maths					
I am good at Maths					
I don't think that I will need Maths for my job when I grow up					
I like arts subjects (Art, Drama, Music)					
Maths lessons are fun					
I will probably go to university					
I think I am quite good at Maths, but probably not good enough to do it at college					
Lots of other people in my Mathematics class are better at it than me					
I enjoy Maths					
I know what I want to do for my career					
I like Maths and science					
When I leave school, I won't do any more Maths qualifications					
Maths makes me worried					
Maths will be useful for my job when I leave school					
Maths is difficult					

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

I find Maths boring					
Maths is useful for my life after school, but maybe not for my job					
Overall I enjoy school					
If my teachers thought I should do Maths at college, I would					
I only do Maths because I have to					
My parents are good at Mathematics					
If my friends were doing Maths at college, I would too					
I put a lot of effort into Maths					
My teachers encourage me to do my best in Maths					
I am good enough at Maths to study it at college					
My friends are good at mathematics					
I think that I will probably achieve my target grade in Maths					
I will get a higher grade than my target in Maths					

	Strongly Disagree	**Disagree**	**Undecided**	**Agree**	**Strongly Agree**
I find it difficult to make myself do my Maths homework					

If I go to university, I hope that what I study will involve Maths					
Maths does not make me worry at all					
I can think of lots of ways that Maths is useful outside of school					

Over to you…….

Please answer the following questions in your own words in the spaces provided

How important is Maths to **you** and why?

How do you feel about your ability in Mathematics? Why do you feel this way?

Appendix Four – Online Questionnaire Key Stages Three and Four

Thank you very much for agreeing to take part in my survey about pupil attitudes towards Mathematics. I hope that you will make the most of this opportunity to share your views and opinions. Your ideas, and those of your classmates will be shared with the Maths Department, and with the University of Southampton in my final written report, although of course, no-one's name will be shared. We hope they will give us some clues about how you feel about Maths.

Claire Walker

- Please tick the statement in each case that applies most to you
- Please be honest and give examples of your experiences
- Remember, if you don't wish to take part, then you don't have to!
- If you do not wish to answer these questions, please skip the question

About you

How old are you? Years: ☐ Months: ☐

School Year: ☐

Are you male or female?

Male ☐ Female ☐

Are you planning to study Maths once you leave school?

Yes ☐ No ☐

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
My parents encourage me to do my best in Maths					
I am good at Maths					
With the career path I have in mind, I don't need to do Maths					
I like arts subjects (Art, Drama, Music)					
Maths lessons are fun					
I will probably go to university					
I will probably get a C or a D grade in Maths					
I think I am quite good at Maths, but probably not good enough to do it at college					
Lots of other people in my Mathematics class are better at it than me					
I enjoy Maths					
I know what I want to do for my career					
I like maths and science subjects					
When I leave school, I won't do any more Maths qualifications					
Maths makes me anxious					
Maths will be useful for my chosen career					

I will study Maths at AS Level					
Maths is difficult					

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I find Maths boring					
Maths is useful for my life after school, but maybe not for my career					
Overall I enjoy school					
I will study Maths at A-Level					
If my teachers thought I should do AS level Maths, I would think about it					
I only do Maths because I have to					
My parents are good at Mathematics					
If my friends were doing maths at college, I would too					
I will probably get an A or a B grade in Maths					
In the career I want, there will be ways that calculations can be worked out for me, and I won't need to do them myself					
I put a lot of effort into Maths					
My teachers encourage me to do my best in Maths					
I am good enough at Mathematics to study it at AS Level					

I don't know what I want to do yet, but feel that A-Level Maths will keep more doors open to me					
My friends are good at mathematics					
I think that I will probably achieve my target grade in Maths					
I will get a higher grade than my target in Mathematics					

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I find it difficult to make myself do my Maths homework					
If I go to university, I hope that what I study will involve mathematics					
I would maybe study some more advanced Maths if I didn't have to do an exam in it					
Maths does not make me worry at all					
I can think of lots of ways that Maths will be useful when I leave school that are not related to the job I want to do					

Over to you……

Please answer the following questions in your own words in the spaces provided

How important is Maths to you and why?

When it comes to making decisions about your mathematics education, for example choosing your AS Level options, or deciding how much effort to put into your mathematics revision, are there any people who might influence your decisions? If so, who are these people?

How do you feel about your ability in Mathematics? Why do you feel this way?

Appendix Five – Participant Information Sheets

Participant Information Sheet-Interviews (version 1 / 27.7.14)

Study Title: The factors which affect the decision of students in England to study mathematics in post-compulsory education: A cross-sectional study

Researcher: Claire Walker **Ethics number**: 20166

Please read this information carefully before deciding to take part in this research. If you are happy to participate, please complete the attached survey and consent form, and return to me at c.walker@wyvern.hants.sch.uk

What is the research about?

I am currently completing my PhD in Mathematics Education at The University of Southampton. The focus of my thesis is the attitude of students in England towards mathematics, and why they might choose not to participate in the study of advanced mathematics after the age of 16, when its study is no longer compulsory. I wish to complete a small pilot study into the perceptions and values of mathematics of learners who have decided definitely either to study, or not study it at AS-Level.

What is involved in taking part in the research?

I would like to talk to you about your opinion of Mathematics. I would like to know how it makes you feel, how important you think it might be for your future, who influences the decisions you make about mathematics and how good at mathematics you think you are and why.

The interviews will take place one lunchtime that is convenient to us both in IT2, and should take around 30 minutes of your time.

Will my participation be confidential?

I will be audio-recording the interview, but will not share the audio recordings with anyone else, or share any of your personal information with them. Your interview material will be stored securely on my computer in compliance with the Data Protection Act and University of Southampton policy, backed up securely online and on a hardrive which will be stored securely.

When I writ e up the interviews for my project, I will make sure that I will not identify you in any way, or include any material that might identify you. All of your interview data will be anonymised in my write up.

What happens if I change my mind?

I will ask you to sign a consent form when we come to interview you, which says that I can use the material from your interview. You can, however, withdraw from the project at any stage and I won't use your interview, up to the point of writing and completion of my study (approximately 12 months after your interview).

Where can I get more information?

If you, or your parents or guardians have any questions about the research project and your participation please contact me using the email details below. I am happy to answer your questions, either by email or you can come and ask me in my classroom, IT2.

You are welcome to read my final report if you are interested/

Ms Walker: c.walker@wyvern.hants.sch.uk

In the unlikely case that you have any concerns or complaints about this study, please contact

The Research Governance Office

George Thomas Building 37
Room 4079

University of Southampton
Highfield
Southampton SO17 1BJ

rgoinfo@soton.ac.uk

023 8059 28848

Appendix Six – Code Book Key Stage One Interviews

Component of Affect	Interview Question	Tags used
Intention to Study/not study maths in post compulsory education	Maths: Yes/No	Y-Yes N-No D-Don't know M-Maybe
	Why has participant decided to study/not to study mathematics?	S-Want to do something else L-Like it G-Get better at it C-Makes you feel clever J-Might be useful for future job Go-Good at it NG-Not Good at it DW-Don't know why I-Generally important DL-Dislike it
Perceived exchange value of mathematics	Does the participant know which job they would like to have in the future?	K-Knows future job DJ-Does not know future job
	Will mathematics be important in their future job?	N-Maths needed in job NN-Maths not needed in job
	Why will mathematics be useful in their future job?	GB-Get better
	Is mathematics useful for adults outside of work?	YA-Yes, adults use maths outside of work NA-No, adults do not do maths outside of work DA-Don't know if adults use maths outside of work
	Explanation of why mathematics is useful for adults outside of work	DWA-Don't know why adults use maths outside of work H-Helping with homework Co-Counting things Da-Dates and times
	Is mathematics important for you outside of school?	YI-Yes, maths is important outside of school NI-No, maths is not important outside of school DI-Don't know SI-Sometimes
	Why is mathematics important for you outside of school?	Hw – Homework Ch-Challenges M-Money/Shopping Ge-Get better Ga-Games O-Named mathematical operations Me-Measuring
Normative influences	Do you know what Sixth Form College is?	KC-Know what sixth form college is DKC-Don't know what sixth form college is

		SC-Some understanding of what sixth form college is
	Who helps you to make important decisions about school?	PD-Parents influential on decisions about school FD-Friends influential on decisions about school TD-Teachers influential on decisions about school OD-Others influential on decisions about school
	Why do you rely on this person to help you make important decisions about school?	W-Wisdom P-Likely to be present at the time A-Authority of person
	Would you do mathematics when you no longer had to if your friends were going to do it?	F-Would do if friends were doing it NF-Friends not influential DF-Don't know if friends are influential
	Why would you do mathematics when you no longer had to if your friends were going to do it?	Co-Enjoys company of friends So-Wants to do something else OD-Wants to make own decision H-Friends help me
	Would you do mathematics when you no longer had to if your teacher wanted you to do it?	T-Would do maths if teacher wanted me to NTI-Teacher not influential
	Why would you do mathematics when you no longer had to if your teacher wanted you to do it?	AT-Authority of Teacher WT-Wisdom of Teacher SoET-Wants to do something else
	Would you do mathematics when you no longer had to if your parents wanted you to do it?	Pa-Would do maths if parents wanted me to NP-Parents not influential
	Why would you do mathematics when you no longer had to if your parents wanted you to do it?	WP-Parents' wisdom AP-Parents Authority SoEP-Want to do something else
Perceived mathematical self-concept	Are you good at numeracy/mathematics?	GN-Good at numeracy NGN-Not good at numeracy DGN-Don't know if good at numeracy SGN-Sort of good at numeracy
	How do you know whether you are good at numeracy/mathematics?	FT- Feedback from teacher AC-Get answers correct MA-Perceives self to be more able than others in

		class CO-Can carry out complex operations (own perception) MD-Finds maths difficult NMD- Does not find maths difficult SMC-Only gets some maths right DKWG-Don't know why I think I'm good/not good at mathematics
Affective Dimension	How does learning maths make you feel?	1-Very Sad 2-A bit Sad 3-Ok 4-Quite Happy 5-Very Happy
	Why does learning mathematics make you feel like this?	GMa-Perceives self to be good at maths R-Repetitive nature of mathematics U-Mathematics is useful LN-Likes to learn to knew things MDi-Maths difficult NG-Does not perceive themselves to be good at maths SD-Sometimes difficult W-Does not like written aspect of maths SA Sense of achievement F Fun
	Do you like or dislike mathematics?	LM-Like mathematics DM-Dislike mathematics S-Sometimes like mathematics
	Why do you like or dislike mathematics?	LN-Likes to learn new things A-Positive perception of own ability U-Useful C-Likes getting things correct
Perceptions of mathematics	Is mathematics easy or difficult?	ME-mathematics is easy MD-Mathematics is difficult ST-Mathematics is sometimes easy and sometimes difficult MED-Mathematics is 'between easy and difficult'
	Why do you think that mathematics is easy or difficult?	KA-Know the answers DO-Depends on operations
Not related to any particular component of affect	Which three words would you use to describe mathematics?	GP – General positive term for mathematics GN – General negative term

		for mathematics GNe- General Neutral term for mathematics PA – Positive Affective dimension NA – Negative Affective dimension L – Positive comment on 'Learning' EF- Easy free choice HF- Hard/Difficult free choice F – Fun U - Positive Utility of Mathematics MO – Reference to a mathematical operation

Component of Attitude	Question	Codes used
Topic Area One: Indication on survey to study/not study mathematics in post-compulsory education	You have indicated in your questionnaire answers that you intend/don't intend to study mathematics in post-compulsory education.	YM-Will study maths in post-compulsory education NM-Will not study maths in post-compulsory education DK-Does not know if they will study maths in post-compulsory education
	Could you tell me a little about why you have decided this?	FS-Favourite subject F-Fun GB-Wants to get better at it I-Important for life in general IJ-Important for job L-I like maths E-I enjoy maths EC-I enjoy the challenge
Perceived Exchange Value of mathematics	Do you know what you want to be when you grow up?	DKJ-Doesn't know what future job will be KJ-Knows what future job will be MIC-Maths important for future career
	What do you want to be when you grow up?	
	How important do you think that mathematics will be for your chosen career?	IC-Important for chosen career NC-Not important for chosen career
	Why?	
	Is mathematics important outside of school?	YI-Yes, mathematics is important to me outside of school NI-No, mathematics is not important to me outside of school
	Why?	B-Might use it for building T-Teachers might use it MG-Uses maths for games S-Uses maths for shopping P-Practicing for SATs H-Homework TE-I like to test myself St-I like to do mental maths if I feel stressed DBS-Working out the days before the summer holidays TM-I teach things to my mum Co-Important for counting
	Do your parents use maths outside of	YP-Yes, my parents use

	work?	mathematics outside of work NP-No, my parents don't use mathematics outside of work
	Why?	MS-Uses maths for shopping MC-Uses maths for cooking J-Job involves maths P-Working out if they have enough petrol for a journey Re-They mostly just relax after work B-Uses maths for paying bills T-Parents use maths for working out the time
Normative influences on decisions made about mathematics	Who are the most important people to you when it comes to making important decisions, for example the decisions you make when you choose what subjects to study after you leave secondary school	PI – Parents influential MI-Mother influential FI – Father influential TI-Teachers influential SI-Siblings influential MD-I make my own decisions
	Why?	KA-They know a lot about me E-They have a lot of experience KB-They know what's best for me FI-Because my friends are going through the same things, so they might have some good ideas PN-Parents need to know what I am doing Lo-They are very loyal
	If your friends chose to study a subject you did not like, would this influence your decision?	FIM-Friends influential on post-compulsory subject decisions FNIM-Friends not influential on decision to study post-compulsory subject decisions FMIM-Friends might be influential on post-compulsory decisions
	Why?	F-Because of impact on own education/future OD-Needs to make own decision I-I'm not very good at it DM-I don't mind if they do different subjects to me MNF-I can make new friends
	If your parents wanted you to study a subject you didn't like would you do it?	PIM-Parents influential on decision to study post-compulsory subject decisions PMIM-Parents might be influential on decision PNIM-Parents not influential on post compulsory subject decisions
	Why?	K-Assumes parent has a good knowledge of subject KB-Assumes parent has a good knowledge of 'what is best for me'

		WOD-Wants to make own decision PA-Perceived parental authority R-Parent must ‘have a reason’ MiGe-I would do it if they thought that I would get somewhere SLT-Because they went to school a long time ago, and things have changed H-Because my mum’s just trying to help DWUM-I don’t want to upset my mum
	If your teacher wanted you to study a subject you didn’t like would you do it?	TIM-Teacher influential on post-compulsory subject decisions TNIM-Teacher not influential on post-compulsory subject decisions TMIM-Teacher might be influential on post-compulsory subject decisions
	Why?	KM-My teacher knows me and so knows what is best for me E-My teacher encourages me TR-Teacher must have a reason WODT-Wants to make own decision PT-Wants to please teacher NR-No reason given H-Because my teacher could help me with things that I don’t understand PD-Parents decision more important
Perceived mathematical self-concept	How do you feel that you are doing in Mathematics?	DW-Doing well at mathematics OK-Doing OK at mathematics M-I think I’m ‘in the middle’
	Why do you think this?	SATS-From my SATS results GMK-Good mathematical knowledge SR-From school report F-Because I’m finding it fun TS-Is in the top set FWQ-Finishes work before others DWT-Does well on tests PM-Practices maths a lot
Affective dimension	How does learning mathematics make you feel?	D-Depends on subject content SH-Sort of happy SSH-Sometimes happy H-Makes me feel happy G-Makes me feel good E-Makes me feel excited C-Makes me feel ready for

		challenges
	Why do you think this?	FS-Favourite subject HWA-Happy when able to complete tasks set C-Likes the feeling of concentration JL-Just really likes maths CP-Enjoying current project MF-Maths is fun FRF-Makes me feel ready for the future LSO-Lists specific operations
	Do you like or dislike mathematics?	LM-Likes mathematics LOM-Loves mathematics DM-Dislikes mathematics S-Sometimes likes mathematics
	Why do you think this?	Wo-Likes to work things out E-I find maths easy F-Maths is a big thing in my family Fu-Maths is fun NT-Not as much thinking as English Me-Likes methodical nature of maths MCS-I like that it's a mixture of challenging and simple SO-Likes specific operations MS-It's my style
Topic Area Six: Perceptions of mathematics	How difficult or easy do you think mathematics is?	ME-Mathematics is easy MD-Mathematics is difficult MS-Mathematics is sometimes easy and sometimes difficult Mid-In the middle QE-Quite Easy
	Why?	SUB-Depends on subject content DC-Differentiated content Su-Good support from school
	If you could three words to describe mathematics, what would they be?	

Appendix Seven – Tags used for Key Stage Three and Four Interviews

Component of Affect	Long answer question	Tags used
	How important is Maths to you?	VI-Very important CME-Maths catches my eye NI-Not important SI-Maths is sometimes important I-Maths is important QI-Maths is quite important DKI-I don't know how important maths is to me NIN-Not important to me personally, but I will probably need it P-I feel like maths is part of me
	How do you feel about your ability in maths?	IGM-I am good at maths IRGM-I am really good at maths CM-I am comfortable with my mathematical ability FG-I feel good about my mathematical ability FI-I feel fine about my mathematical ability SI-I feel intelligent, but not the best AA-Above average A-I am average at maths BA-Below average CO-I feel confident SC-Sometimes confident SA-I feel sad about my mathematical ability OK-I am ok at maths QG-I am quite good at maths NG-I am not good at maths H-I feel happy about maths GMDE-I am good at maths, but I don't enjoy it LG-I get low grades even though I get all of the questions right RI-There is room for improvement DIM-I am disappointed in my mathematical ability NGM-I am not good at maths DKA-I don't know how I feel about my mathematical ability GL-Good when I listen

	Who helps you to make important decisions about school?	PI-Parents influential NSI-I am not sure who is influential upon my decisions MI-Mother influential TI-Teachers are influential TU-Private tutor influential FI-Friends influential BI-My brother is influential NE-There are no external influences upon me FAI-Father influential GI-Grandparents influential FAMI-Family influential LE-Lots of effort E-Everyone around me is putting in loads of work, so I do too.
1.Perceived exchange value of mathematics	Why is maths important/not important to you?	CC-Maths is important for my chosen career NCC-Maths is not important for my chosen career EDL-Maths is important for everyday life GJ-Mathematics is important to get any good job US-Its useful for some things NU-We learn some things which aren't useful in our everyday lives PO-People in poor countries don't get this opportunity OP-Maths gives you options later in life DWR-I don't want to repeat it at A-Level CO-I need it to get into college
	Why do you feel this way about your mathematical ability?	
	Why is this person/people influential?	
2.Normative influences	Why is maths important/not important to you?	DMA-My Dad does maths as a job
	Why do you feel this way about your mathematical ability?	SU-I am well supported PC-Other people comment positively on my mathematical abilities
	Why is this person/people influential?	GM-This person is good at maths EM-This person encourages me TW-This person is trustworthy

		GI-This person is globally influential upon me NG-This person is not good at maths Ex-This person is more experienced than me PGM-This person is good at maths and would like me to study it PDM-My parents want me to do my best AG-This person encourages me to reach my goals OW-Everything I do is my own work KM-This person knows me SUP-This person supports me
3.Perceived mathematical self-concept	Why is maths important/not important to you?	IGMA-I am good at maths BA-Maths is important, but I am really bad at it BM-I am better at maths than I am at other subjects BS-It is my best subject
	Why do you feel this way about your mathematical ability?	GSATS-Good SATs scores GT-Good test scores RE-We are revising content that I have previously mastered GMA-I am good at maths TS-I am in the top set for maths PM-I practise maths a lot at home WH-I work hard in mathematics lessons PE- I persevere TQ-I can do the tricky questions DB-I don't believe that I can do it GB-I am getting better at maths LMP-I have been learning maths since primary school CDI-I can't do lots of things NTNB-I am not at the top of the class, but I am not at the bottom NW-I am not the worst U-I understand what we are doing DS-I don't struggle PRO-I'm making progress DU-I don't understand what

		we are doing MBPS-I am missing the basics from Primary School
	Why is this person/people influential?	
4.Affective Dimension	Why is maths important/not important to you?	E-I enjoy working out the questions DE-I don't enjoy/like maths IP-I'm more of an imaginative person NC-I am not confident with maths
	Why do you feel this way about your mathematical ability?	EM-Because I enjoy maths TB-Because I try my best PO-I prefer other subjects SS-I sometimes struggle FS-Maths is my favourite subject
	Why is this person/people influential?	
5.Perceptions of mathematics	Why is maths important/not important to you?	GL-Maths is good to learn WT-In maths you work things out systematically without having to know things BT-Maths teaches us basic things DI-Maths is difficult BO-Maths is boring P-Maths is important to me, but only if it is practical PL-It's part of life CG-It is a crucial GCSE subject DA-It has definite answers IFME-I find maths easy TE-Technology can work out calculations for you
	Why do you feel this way about your mathematical ability?	H-Maths is just so hard ME-Maths is easy
	Why is this person/people influential?	

Appendix Eight – Semi structured interview schedule

Topic Area	**Prompts**
Introduction	Introduce self, explain my project and discuss any questions from participant arising
Topic Area One: Indication on survey to study/not study mathematics in post-compulsory education	You have indicated in your questionnaire answers that you intend/don't intend to study mathematics in post-compulsory education. Could you tell me a little about why you have decided this?
Topic Area Two: Perceived Exchange Value of mathematics	How important do you think that mathematics will be for your chosen career? Why? How important do you think mathematics is for your life now and after you leave school outside of work? Why?
Topic Area Three: External influences on decisions made about mathematics	Who are the most important people to you when it comes to making important decisions, for example the decisions you make when you choose what subjects to study after you leave secondary school? Are your friends likely to study mathematics at sixth form college? If your friends chose to study mathematics would this influence your decision? If your parents wanted you to study mathematics would you choose it at AS-level?
Topic Area Four: Perceived mathematical self-concept	What do you feel that your ability is in mathematics? Why do you think this?
Topic Area Five: Affective	How does learning mathematics make you feel?

dimension	Do you like or dislike mathematics?
Topic Area Six: Perceptions of mathematics	How difficult or easy do you think mathematics is? If you could three words to describe mathematics, what would they be?

Appendix Nine – What were students learning at each Key Stage?

Key Stage One

Mathematics examinations were split into arithmetic and reasoning respectively. In the arithmetic paper, students are expected to complete basic arithmetical calculations multiplication division, subtraction and addition. In addition to simple calculations (e.g. 2 + 1 =) students were also expected to complete equations more algebraic in form (e.g. 2 +   =6). Students needed to complete addition using three values (3+4+5=). They were also expected to be able to complete some basic fractions ($\frac{1}{2}$ of 16 =).

In the reasoning paper, students are asked questions directly related to the everyday situations in which they might be required to use mathematics rather than the more abstract arithmetic paper. Students are expected to complete mathematics related logic questions which involve reading and understanding words related to values such as ‘most’ and ‘least’ e.g they might be asked to sort images of containers from most to least full, or if Amy has three shells, and Abdul has three more shells than Amy, how many shells does Abdul have?. They are tested on their knowledge of money e.g. being able to identify that 5p is of less value than 20p. They need to understand the various representations of number so for example could be expected to understand that ‘99’ and ‘ninety nine’ are of equal value, or be able to equate tally charts to numerical values, and they could be asked to complete missing values on a number line. They are tested on their understanding of geometry and related vocabulary, for example understanding that symmetry means that both sides of the shape are the same. At this stage, students were also expected to know the names of 2D shapes such as ‘pentagon’ and ‘octagon’. They need to be able to shade fractions of a shape e.g. $\frac{3}{4}$ of a square. They also should understand some basic translations such as identifying a full turn and half a turn when shown a rotated image. In addition in this paper students demonstrate an understanding of weights and measures such as being able to articulate the numerical value shown on weighing scales, and are required to demonstrate an understanding of distance e.g. if Abdul has completed three lengths of a hundred metre swimming pool, how far has he swum?. In this paper students were expected to demonstrate an understanding of time, e.g. ‘Which clock face shows ten past one?’. Students were expected to use > < to show which equation was worth the highest value e.g. $3+4 < 3 \times 4$.

Key Stage Two

The mathematics curriculum at Key Stage 2 is divided into a number of Key Performance Indicators (KPIs). In general, the national curriculum at Key Stage 2 aims to ensure that students become fluent in the fundamentals of mathematics, and are able to recall and apply knowledge rapidly and accurately. Students should also be able to reason mathematically, following lines of enquiry and developing arguments. They should be able to apply their mathematical knowledge to routine and non-routine problems.

Year four participants are half way through Key Stage 2. By the end of Year 4 they should be able to solve a range of problems including those with simple fractions (e.g. being able to recognise families of common equivalent fractions) and decimal places (e.g. they should be able to count up and down in hundreds and know that hundredths arise when dividing an object by 100). They should be able to apply knowledge of decimal places to measure and money. They should be able to draw shapes and describe the relationships between them, and use measuring instruments. They should also be able to convert between different units of measure such as kilometres to metres. They should be able to recall up to and including the 12 multiplication table. They should also be able to read and spell mathematical vocabulary accurately. Additionally, they should have some statistical knowledge, including how to represent information in a variety of formats, including bar charts and tables.

Year 6 participants are at the end of Key Stage Two, and at the time of completing the online questionnaire were preparing for Key Stage Two SATs examinations. Whilst these have no particular exchange value to students as such, they are a performance indicator for Primary schools. Additionally, the grades attained in these exams (an average of their reading examination score, and their mathematics attainment scores) are passed to their future secondary schools. Whilst there is no particular exchange value in these results, they are considered to be both high stakes for students as well as for their school. By the time they reach their SATs examinations, students should be fluent in all four mathematical operations (including formal written long multiplication and division and interpret remainders). They should be able to use division methods where the answer could have up to two decimal places. They should begin to be able to use and understand algebraic terms, and use simple algebraic formulae. They should be fluent in the use of fractions, decimals, percentages and ratio. They should be able to use negative numbers within context and calculate intervals across zero. In terms of shape and space, they should be able to find unknown angles in triangles, quadrilaterals and polygons. They should also be able to draw and translate simple shapes on the coordinate plane, and interpret pie and line graphs. In terms of their statistical knowledge, they should be able to interpret the mean as an average.

When interviewed students discussed these concepts, and in some instances bought their books with them to show specific examples. Their perceptions of what they had learnt and the manner in which they were taught are discussed later in the following chapters

When participating in the semi-structured interviews, a number of participants made reference to what they had been learning in maths, and how this had been taught to them. One student bought her book with her. These opportunities provided some useful context to how the KPIs are approached, and how the school successfully attempted to engage students with mathematical content. In comparison with the data collected from KS1 students, the number of incidences of students making reference to the specific content of their lessons was noticeable.

In the cases of students both in Years 4 and 6, the discrete mathematics that had previously been taught was contextualised in longer integrated projects that also included elements of literacy and humanities subjects. In July, students in Year 4 were participating in a project based upon ‘Testwood Lakes’ and Year 6 in a project based upon ‘Theme Parks’. In these projects, students applied their arithmetical knowledge to real world problems. One participant gave the example of calculating profit and loss in his theme park project. For the Year 4 Testwood Lakes project, students had attended a field trip the day prior to the interviews. They had taken part in activities such as pond dipping, walking and making a ‘waste free lunch’. The mathematical knowledge necessary was calculating the cost of materials for creating amenities, creating timetables for visitors depending on how long they might like to spend at the lakes, and including given angles in the toilet blocks. Students were reading ‘Wind in the Willows’ as a class, and this has also been incorporated. They were asked to consider the best way for Rat and Mole to visit Testwood Lakes, and needed to work out the most cost effective transport for them.

Students also made reference to repetitive practice, for example ‘We’ve got a list of 30 numbers where we times them’. They made reference to the methodological approaches taken to mathematical problem solving; for example ‘The bus stop method’ for division, and the column method for addition. Elements of literacy were incorporated into mathematical learning, for example students were asked to use ‘Point, Evidence, Explain’ to justify choices in problem solving.

Students were divided into ability groups for mathematics. Even though they were taught in the same classroom, they were seated on tables with those of similar aptitude. For each topic, students took part in some pre-testing. This was presented in a positive, low-stakes way to students. The pre-tests were called ‘pink tasks’, and students were told that they were for ‘showing off your knowledge about the new topic’. From the pre-testing, they were then identified as: not knowing anything at all, knowing a little about the topic, or being confident in the topic. Those who were identified as students who may potentially struggle were given some ‘pre-teaching’ to ensure a more secure understanding before official whole class teaching of the given topic.

Students’ work was marked in either green or pink pen. If the marking was green, then the work was correct and no further action was needed on the part of the student. If the marking was pink, then the work was incorrect and the student needed to attempt the work again using a purple pen. There was also evidence of peer-assessment.

References

Alwyn, D, (1997) Feeling Thermometer Versus 7-Point Scales *Sociological Methods and Research,* 25 (3), 318-340

Ambrose, R, Clement, L, Philip, R, Chauvot, J, (2003) Assessing Prospective Elementary Teachers' Beliefs About Mathematics and Mathematics Learning: Rationale and Development of a Constructed-Response-Format Beliefs Survey *School Science and Mathematics* 104(2); 56-69

Archer, L., Osbourne, J., DeWitt, J., Dillon, J., Wong, B. and Willis, B. (2013) ASPIRES: Young people's science and career aspirations, age 10-14.London: Kings College London

Armitage, J. and Conner, M. (2001) Efficacy of the Theory of Planned Behaviour: A meta-analytic review *British Journal of Social Psychology*, 40, 471-499

Ashby, B. (2009) Exploring Children's Attitudes towards Mathematics *Proceedings of the British Society for Research into Learning Mathematics,* 29(1), 7-12

Ashcraft and Kirk (2007) The Relationships Among Working Memory, Math Anxiety, and Performance ; *Journal of Experimental Psychology*; 14(2), 243-248

Ashcraft and Krause(2007) Working memory, math performance, and math anxiety; *Psychonomic Bulletin and Review*; 12,165-170

Azjen, I. (1991) The theory of planned behaviour *Organizational Behaviour & Human Decision Processes*, 50, 179-211

Baldwin, J (1905) Dictionary of Philosophy and Psychology Oxford:Clarendon

Banet, E., and Nunez, F., (1997), Teaching and Learning about human nutrition: A constructivist approach. International Journal of Science Education, 19, 1169-1194

Batcho, K,I, Nave, A, DaRin (2011) A Retrospective study of Childhood Experiences *Journal of Happiness Studies*, 12, 531-545

Bechhofer F, Paterson L (2012) Principles of Research Design in the Social Sciences. Routledge

BERA (2011) Ethical Guidelines for Education Research, London, BERA

Bergem, O. (2016) "Mathematics Is My Favorite Subject!" Variation in Instructional Practices Boosting Students' Attitudes Towards Mathematics; *Teaching and Learning in Lower Secondary Schools in the Era of PISA and TIMSS, Professional Learning and Development in Schools and Higher Education 12*, Switzerland:Springer

Biddle B., Bank, B. and Slavings, R. (2002) Toward a Social Psychology of Place: Predicting Behavior from Place-Based Cognitions, Attitude, and Identity *Environment and Behavior*, 34, 561-581,

Black L., Williams, J., Hernandes-Martinez, P., Davis, P., Pampaka, M. and Wake G. (2009) Developing a 'leading identity': the relationship between students' mathematical identities and their career and higher education aspirations *Educ Stud Math*, 73, 55-72

Boaler, J. (1997) Reclaiming School Mathematics: The girls fight back, *Gender and Education*, 9(3), 285-305

Boaler, J., and Greeno, J. (2000) Identity, agency, and knowing in mathematical worlds. In J. Boaler (Ed.),*Multiple perspectives on mathematics teaching and learning*, Stamford, CT: Ablex.

Borthwick, A. (2011) Children's perceptions of, and attitudes towards, their mathematics lessons *Proceedings of the British Society for Research into Learning Mathematics*, 31(1), 37-42

Bourdieu, P. (1973) Cultural Reproduction and Social Reproduction; *Knowledge, Education, and Cultural Change: Papers in the Sociology of Education,* 71-112

Brown, M., Brown, P. and Bibby T., (2007) "I would rather die": Reasons given by 16 year olds for not continuing their study of mathematics, *Research in mathematics education*, 10 (1), 3-18

Buck, N., Emisch, J. and Jenkins, S. (1995) *Choosing a Longitudinal Survey Design: The Issues*, New Zealand Treasury

Burke Johnson, R., and Onwuegbuzie, A. (2004) Mixed Methods Research: A Research Paradigm Whose Time Has Come *Educational Researcher*, 33(7), 14-26

Bryman, A, (2008) *Social Research Methods*, 3rd Edition, Oxford: Oxford University Press

Charng,H., Piliavin,J., and Callero,P. (1988) Role identity and reasoned action in the prediction of repeated behavior *Social Psychology Quarterly*, 51, 303-317

Christensen P., and James, A. (2008) Research with Children: Perspectives and Practices, Oxford: Routledge

Clason, D., and Dormody, T. (1994) Analyzing Data measured by individual Likert items *Journal of Agricultural Education*, 35(4), 31-35

Cockcroft, W. (1982), Mathematics counts: report of the Committee of Inquiry into the teaching of mathematics in schools. London: HMSO

Cohen, L., Manion, L., and Morrison, K., (2008) *Research Methods in Education.* Oxford: Routledge

de Lourdes Mata, M., Monteiro, V. and Peixto, F. (2012) Attitudes towards Mathematics: Effects of Individual, Motivational and Social Support Factors *Child Development Research,* 2012, 1-10

Department for Education, (2010*), Maths and science education: the supply of high achievers at A-Level.* London: DfES

Department for Education and Gibb, N, (2014*), Launch of new high quality post-16 maths qualifications*, Available from <https://www.gov.uk/government/news/launch-of-new-high-quality-post-16-maths-qualifications> [29 December 2015]

Department for Education (2014) *Participation of young people in education, employment or training Statutory guidance for local authorities*. London:DfE

Department for Education (2014) *Assessment, curriculum and qualifications Research priorities and question.*; London:DfE

Department for Education (2015) *Core maths qualifications: technical guidance*. London: DfE

De Bellis, V., and Goldin, G. (2006). Affect and Meta-Affect in Mathematical Problem solving: A representational perspective *Educational Studies in Mathematics,* 63, 131–147

Di Martino, P. and Zan, R. (2009) 'Me and maths': towards a definition of attitude grounded on students' narratives *Journal of mathematics teacher education*, 13, 27-48

Di Martino, P. and Zan, R. (2011) Attitude towards mathematics: a bridge between beliefs and emotions *ZDM,* 43 (4), 471-482

Dowker, A, Bennett, K, Smith, L (2012); Attitudes to Mathematics in Primary School Children; *Child Development Research*; pp. 1-8

Dumais, S. (2002) Cultural capital, gender, and school success: the role of habitus. *Sociology of Education*, 75, 44–68

Dyer, C. (1995); *Beginning research in Psychology;* Oxford: Blackwell

Epstein, D., Mendick, H. and Moreau, M-P (2010) Imagining the mathematician: young people talking about popular representations of maths; *Discourse: Studies in the Cultural Politics of Education*, 31; 45-60

Eagly, A. and Chaiken, S. (1993) *The psychology of attitudes.* Orlando: Harcourt Brace Jovanovich College Publishers

Fazio, R. and Roskos-Ewoldsen, D. (2004) *Persuasion; Acting as we feel: When and How Attitudes Guide Behaviour,* 2nd Ed, 41-62

Fine, K. and Sandstrom, G. (1988) *Knowing Children: Participant observations with minors,* Newbury Park CA:Sage

Fishbein, M, (1967) *Readings in Attitude Theory and Measurement*, Illinois:John Wiley and Sons

Fishbein M. and Azjen, A. (1975); *Beliefs, attitude, intention and behaviour: An Introduction to theory and research*, Reading MA: Addison Wesley

Gal, I., and Ginsberg, L. (1994) The role of beliefs and attitudes in Learning Statistics: Towards an assessment framework, *Journal of Statistics Education*,[online] 2:2

Glaesser, J. and Cooper, B. (2014) Using Rational Action Theory and Bourdieu's Habitus Theory Together to Account for Educational Decision-making in England and Germany; *Sociology*, 48(3), 463 –481

Gorard, S. and Taylor, C. (2004) *Combining Methods in Educational and Social Research,* Bell and Bain:Glasgow

Green, S.K., (2002). Using an expectancy-value approach to examine teacher's motivational strategies. Teaching and Teacher Education, 18, 989-1005

Groves, R., Fowler, F., Couper, M., Lepkowski, J., Singer, E. and Tourangeau, R., (2006) *Survey Methodology*, 2nd Ed, Hoboken New Jersey:Wiley

Hannula, M. (2007) Finnish Research on affect in mathematics: blended theories, mixed methods and some findings *ZDM Mathematics Education*, 39, 197-203

Hannula M. (2002) Attitudes towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics,* 49, 25-46

Hernandez-Martinez, P., Black, L., Williams, J., Davis., Pampaka, and Wake, G. (2008) Mathematics students' aspirations for higher education: class, ethnicity, gender and interpretive repertoire styles; *Research Papers in Education*, 23 (2), 153-165

Hodgen,J., Kuchemann, D., Brown, M. and Coe, R. (2009) Lower secondary school students' attitudes towards mathematics: evidence from a large scale survey in England, *Proceedings of the British Society for Research into Learning Mathematics*, 29 (3),49-54

Hodgen, J., Marks,R., and Pepper, D. (2013) Towards universal participation in post-16 mathematics: lessons from high performing countries, London: The Nuffield Foundation

Hogg, M. and Vaughan, G. (2011) *Social Psychology*; 6th Ed, Harlow:Prentice Hall

Holm, M.J., Hannula, M., Bjorn, P. (2017) Mathematics-related emotions among Finnish adolescents across different performance levels *An International Journal of Experimental Psychology*, 37 (2), 205-218

Jones, R.,(2008) Students' participation in post-16 mathematics: a perspective from students in Wales *Educational Futures*, 1 (1), 71-78

Kothari, C. (2004) *Research methodology: Methods and Techniques*, New Dehli, New Age International Publishers

La Piere, R. (1934) Attitudes vs Actions *Social Forces*, 13, 230-237

Ma, X. and Kishor N. (1997) Assessing the relationship between attitude towards mathematics and achievement in mathematics *Journal for Research in Mathematics Education,* 28 (1), 27-47.

Mackenzie, N. and Knipe, S. (2006) Research Dilemmas: Paradigms, methods and methodology *Issues in Education Research*, 16, 193-205

Maloney, E. and Beilock, S. (2012) Math anxiety: who has it, why it develops and how to guard against it, *Trends in Cognitive Sciences*, 16, 404-406

Mayall, B., (2008) Conversations with Children; Working with Generational Issues, In *Research with Children, Perspectives and Practices*, Oxford: Routledge

McDonough, A. and Sullivan, P. (2014) Seeking insights into young children's beliefs about mathematics and learning *Educ Stud Math*, 87, 279-296

McLeod, D. (1992) Research on affect in Mathematics Education: A reconceptualization. In DA Grows (Ed), *Handbook of research on mathematics teaching and learning*, 574-596, New York: Macmillan

McLeod, D. (1994) Research on Affect and Mathematics Learning in the JRME: 1970 to the Present *Journal for Research in Mathematics Education*, 25 (6), 637-647

Menard, S. (1992) Demographic and Theoretical Variables in the Age-Period-Cohort Analysis of Illegal Behaviour *Journal of Crime and Delinquency* 32, 136-174

Martínez-Sierra, G. and García-González, (2017) International Journal of Science and Mathematics Education 15: 349-369

Mendick, H., Hollingworth, S., Moreau, M. and Epstein D., (2007) Being a sumbody; *Proceedings into the British Society for Research into Learning Mathematics*, 27 (3), 84-89

Mujtaba, T., Hoyles, C., Reiss M., Stylianidou, F., and Riazi-Farzad, B., (2010), Mathematics and Physics participation in the UK: *Influences based on analysis of national survey results*, BERA

Mujtaba, T., and Reiss, M.J., (2014) A survey of psychological, motivational, family and perceptions that explain 15 year students' aspirations to study post-compulsory physics in English schools, International Journal of Science and Mathematics Education, 12, 371-393

Murray, S. (2011), Declining participation in post-compulsory secondary school mathematics: students' views and solutions to the problem, *Research in Mathematics Education*, 13(3), 269-285.

National Research Council (2002) *Scientific Research in Education*: Washington: National Academy Press

National Audit Office (2008) *Young People's Attitudes to Mathematics A Research Study Among 11-13 Year Olds on behalf of The National Audit Office,* Ipsos MORI Young People Omnibus 2008 conducted for The National Audit Office

Nardi, E. and Steward, S., (2003) Is Mathematics T.I.R.E.D? A Profile of Quiet Disaffection in the Secondary Mathematics Classroom, *British Educational Research Journal*, 29(3), 345-367.

Neale, D. (1969). The role of attitudes in learning mathematics; *The Arithmetic teacher*, Dec. 1969, 631-641.

Nicolaidou, M. and Philippou, G. (2003) Attitudes towards mathematics, self-efficacy and achievement in problem solving, CERME 3

Noyes, A. (2009) Exploring social patterns of participation in university-entrance level mathematics in England, *Research in Mathematics Education*, 11(2), 167-183

Noyes, A. and Sealey, P., (2012) Investigating participation in Advanced level mathematics: A study of student drop-out, *Research Papers in Education*, 27(1), 123-138.

OECD (2013), PISA 2012 Results: *Ready to Learn: Students' Engagement, Drive and Self-Beliefs (Volume III*), PISA, OECD Publishing

Ofqual (2017) *Perceptions of subject difficulty and subject choices: Are the two linked, and if so, how?*

Osgood, C., Suci, G., and Tannenbaum, P. (1957) *The measurement of meaning.* Urbana, IL: University of Illinois Press

Pampaka, M., Williams, J., Hutcheson, G., Wake, G., Black, .L Davis, P. and Hernandez-Martinez, P (2011) The association between mathematics pedagogy and learners dispositions for university study *British Educational Research Journal*, 38(3), 473-49

Preiss-Goben, H., and Hyde, J. (2016) Implicit Theories, Expectancies, and Values Predict Mathematics Motivation and Behavior across High School and College *Journal of Youth Adolescence* 46, 1318-1332

Punaro, L., and Reeve, R., (2012) Relationships between 9-Year-Olds' Math and Literacy Worries and Mathematical Abilities *Child Development Research*, 2012, 1-11

Rakoczy, K., Harks, B., Klieme, E., Blum, W., and Hochweber, J. (2013) Written Feedback in Mathematics: Mediated by students' perception, moderated by goal orientation *Learning and Instruction,* 27, 63-73

Ramirez, G., Gunderson, E.A., Levine S. and Beilock ,S (2012) Math Anxiety, Working Memory and Math Achievement in Early Elementary School *Journal of Cognition and Development,* 14(2),187–202

Raved, L and Assaraf,O. (2010) Attitudes towards Science Learning among 10th grade students: A qualitative look *International Journal of Science Education*, 33(9) 1-25

Reay, D., Crozier, G. and Clayton, J. (2009) Strangers in Paradise? Working-class Students in Elite Universities *Sociology*, 43(6), 1103-1121

Reiss, M.J., and Mujtaba, T. (2017) Should we embed careers education in STEM lessons? *The Curriculum Journal* 28 (1), 137-150

Rodd, M, Mujtaba, T and Reiss, M, (2010) Participation in mathematics post-18: Undergraduates' stories *Proceedings of the British Congress for Mathematics Education*, April 2012, 175-182

Ruffell, M. Mason, J. and Allen, B. (1998) Studying Attitude to Mathematics *Educational Studies in Mathematics*, 35, 1-18.

Scott, J, (2008) Children as respondents The Challenge for Quantitative Methods In *Research with Children, Perspectives and Practices*, Oxford: Routledge

Schukajlow, S., Rakoczy, K., and Pekrun, R. (2017) *ZDM Mathematics Education* 49, 307-322

Smith, A. (2004) *Making Mathematics count-the report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education.* London: DfES

Smith, C., (2010) Choosing more mathematics: happiness through work? *Research in Mathematics Education*, 12(2), 99-115

Solga (2001) Longitudinal Surveys and the Study of Occupational Mobility: Panel and retrospective Design in Comparison *Quality and Quantity*, 35, 291-309

Stols, G. and Kriek, J. (2011) Why don't all maths teachers use dynamic geometry software in their classrooms? *Australasian Journal of Educational Technology*, 27(1), 137-151

Taylor, B., Francis, B., Archer, L., Hodgen, J., Pepper, D., Tereschenko, A., and Travers, M., (2017) Factors deterring schools from mixed attainment teaching practice *Pedagogy, Culture and Society*, 25 (3)

Terry, D, Hogg, M, and White K (1999) The theory of planned behaviour: Self-identity, social identity and group norms *British Journal of Social Psychology*, 38, 255-244

The Royal Society, (2008), *Science and Mathematics Education: 14-19, A 'state of the nation report on the participation and attainment of 14-19 year olds in science and mathematics in the UK, 1996-2007,* London: The Royal Society

van Laerhoven, H, van der Zaag-Loonen, HJ, Derkx, BHF (2004) A comparison of Likert Scale and visual analogue scales as response options in children's questionnaires *Acta Paediatr* 93, 830-835

Van der Beek, J. Van Der Ven, S., Kroesbergen, E.H. and Leseman, P. (2017) Self-concept mediates the relationship between achievement and emotions in mathematics *British Journal of Psychology*, 87, 478-485

Walls, F. (2009) *Mathematical Subjects: Children Talk About Their Mathematical Lives* Springer New York: Science+Business Media

Warren, H. (1934) *Dictionary of Psychology* Boston:Houghton Mifflin

West, A., Hailes, J., Sammons, P. (1997) Children's Attitudes to the National Curriculum at Key Stage One; *British Educational Research Journal*, 23 (5), 597-613

Young, C., Wu, S., and Menon, V. (2012) The Neurodevelopmental Basis of Math Anxiety. Psychological Science OnlineFirst, published on March 20, 1-10 doi:10.1177/0956797611429134

Zan, R. & Di Martino, P. (2007) Attitude toward Mathematics: overcoming the positive/negative dichotomy *The Montana Mathematics Enthusiast*, 3, 157-68