An exploration of adults' perceptions in identifying strategies to support them in learning mathematics as they embark on an undergraduate degree course in Applied Education Studies

by

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Finally, I dedicate this study to my Dad, who sadly passed away in March of this year and who did not get the chance to see me complete my studies. This one's for you Dad!

Declaration of Inclusion of Material

The pilot study referred to in Chapter 3 formed the basis of a journal article referenced herein as Wicks (2011)

The initial findings discussed in relation to the audit, pre-teaching questionnaire and post-teaching questionnaire formed the basis of a journal article referenced herein as Wicks (2014)

Abstract

The purpose of this research was to explore the perceptions of a cohort of first year undergraduate students embarking on their undergraduate degree in Applied Education Studies in order to identify any strategies that might be seen to support them in learning mathematics. The research stemmed from an initial tracking of first year undergraduate students over a period of four years prior to the start of this research, whereby the mathematics education units were identified as the ones that they were most anxious about. As the majority of the students on the degree course worked with children as unqualified teachers or teaching assistants, and many planned to go on and train as teachers, I wanted to explore the possibility that there may be strategies to support them in becoming more confident in learning mathematics. Concerns linked to adults passing on their anxieties to children they work with was an issue that I was aware of (Hembree 1990; Haylock, 2010) and I wanted to support the students with the aim of avoiding this outcome.

The study tracked a cohort of 75 first year undergraduate students through their first year of study and data was collected via audits, questionnaires and focus group discussions. Students identified that there were three key themes affecting them in learning mathematics: the role of the teacher, their personal perceptions and working with others. However, the overriding factors that were identified by the students in affecting their ability to learn mathematics were the effect of the teacher and the teaching strategies used. As a result of this, seven strategies for supporting adults in learning mathematics have been identified for further consideration.

Chapter 1: Introduction

1.1 Objectives

The purpose of this section is to introduce the focus for this project, and in doing so to provide the context and background to the study; therefore the objectives of this chapter are as follows:

- To introduce the research focus, providing the background and rationale behind the project
- Background to the research setting
- To provide an overview of the content of the thesis

1.2 The Research Focus

Over the past 28 years I have had the opportunity to teach mathematics to both children and adults within a range of contexts. My school based teaching experience initially focussed in primary and middle schools, and my roles included those of class teacher, mathematics specialist and head of a mathematics department. I then moved on to teaching mathematics to adults, initially as a numeracy consultant leading on mathematics training for teachers, teaching assistants and head teachers, and then onto my current role as a Senior Lecturer in Mathematics Education on a BA Applied Education Studies course within a University in the East of England. Throughout my career, I have observed both pupils and adults who have negative perceptions regarding mathematics, more so, seemingly than other subjects within the curriculum. In my current role, which aims to prepare students for working within primary education, it has been apparent that of all of the units that are studied, it is often the mathematics units that are of most concern to them.

In the current educational climate, concerns regarding perceptions of mathematics remain in the foreground, and it appears that in the UK it is ‘ok’ to be negative about mathematics in a way that would not be considered within other cultures and may even be something to be proud of! (DCSF, 2008; Wolfe, 2014). Marsh exemplifies this perception suggesting that ‘We are a nation quite happy to admit to being ‘bad at maths’; we see people almost wearing it as a badge of honour, in a way they would never admit to saying that they couldn’t read or write’ (NIACE, 2011,p.3). The current UK Government also has concerns about low levels of numeracy in relation to the academic qualifications taken by 14 to 16 year olds, the General Certificate of Education (GCSE) and acknowledges the issues identified by Wolf (2011), who suggests that those who do not achieve mathematics Grade C GCSE by the age of sixteen are likely to find it difficult to maintain gainful employment. As such pupils who do not gain grade C by this age will need to continue to study the subject beyond sixteen (Gove, 2013). Alongside this, in response to concerns that low levels of numeracy are impacting on the UK economy (Pro Bono Economics, 2014) the National Numeracy Team aim to support adults in learning mathematics, and advocates that a change of attitude towards the subject may help with this process (2014). In addition to these considerations, it has been identified that where unconfident adults work with children in learning mathematics, there is a concern that their anxieties may be passed onto the pupils they work with, particularly within primary education (Haylock, 2010; Hembree, 1990).

The focus for my research stems from these concerns regarding the apparently negative perceptions that some adults display towards learning mathematics and the potential that these perceptions may be passed on to the pupils they work with.

Potter (2006) advises that there may be many reasons for carrying out post-graduate research, and my reason aligned with that of wanting '... to be able to make a difference ... ' (p.23), in that I wanted to see if there were any factors that might support adults in learning mathematics, particularly as the adults that I work with tend to work with children in primary schools. I therefore focussed this project on a cohort of 75 part-time undergraduate students and tracked them through the first year of their undergraduate studies, in order to explore their views as the year progressed. I wanted to establish what their perceptions of learning mathematics were before and after completing their first mathematics education unit, whether there were any changes in their perceptions and if so, what factors affected these changes. Hence, my overall research aim was identified:

> To explore adults' perceptions in identifying strategies to support them in learning mathematics as they embark on an undergraduate degree course in Applied Education Studies

1.3 Background to the research setting

The University in which the study took place is a relatively new one, established from a partnership of two universities in 2006. The University identifies a commitment to part-time students and the widening participation agenda (Welcome from the Vice Chancellor, 2014), of which the BA Applied Education Studies Course aims to support. Students who attend the course study part-time, either one day a week (9.30 am to 3.30 pm) or one evening a week (4.00 to 8.30 pm) and all are required to be based in a school for at least one day a week. As such, the students who enrol on the course have a variety of school based roles, including teaching assistants, unqualified teachers and volunteers. Students are accepted on the course from ‘non-traditional’ routes and experience in education is considered alongside traditional qualifications. This often means that many of the students have had a break in education since leaving school and returning to more formal study and do not have the qualifications usually accepted for study within higher education. The course has links with Initial Teacher Training (ITT) providers and students often go on to train as teachers once their degree is complete. As students commence their introductory unit on the degree course, they complete audits for the core curriculum areas of English, mathematics and science, as well as ICT. From these audits it has been possible to identify a trend over a number of years where students have consistently expressed anxiety regarding the mathematics units.

The BA (Hons) Applied Education Studies course covers a range of units pertinent to working within primary education. These include core subject units on mathematics, English and science which focus on both subject knowledge content and pedagogical development, as well as generalised curriculum based units. Alongside this there are units which focus on the wider issues within primary education, such as inclusion, teaching and learning, and the professional skills required to work within educational settings. There is also a focus on the development of the students’ research skills, culminating in a final research project completed in the final year of study. Each unit runs over a period of consecutive weeks, and, with the exception of the research project, the teaching for one unit is completed before another begins – usually a five to six week cycle. A full list of the units studied over the duration of the course can be found in Appendix A.

There are three core units on mathematics education based on the development of personal subject knowledge, the pedagogical understanding of teaching mathematics to primary aged pupils and the role of problem solving within the mathematics curriculum. A point to note here is that the focus on subject knowledge supports the development of students' understanding of mathematics up to Grade C GCSE , as Grade C in mathematics is one of the basic requirements for application for teacher training (DfE, 2014). As these students may embark on this degree course from non-traditional routes, subject knowledge content is included to this level to aid the understanding in order to support the process of transition into initial teacher training.

The focus for this research is based on the perceptions of students before and after the completion of the first year mathematics unit, 'Introduction to Mathematics Education', where the aim is to develop a good grounding in basic mathematical concepts alongside how these might be taught. As I was the teacher for this unit, consideration of the potential implications of my role are considered within the methodology. The areas that were covered during the unit and the accompanying assessment requirements are summarised in Table 1.1.

Content area	Coverage
Number	The teaching of place value The teaching and progression of calculation (mental and written)
Fractions, Decimals and Percentages	Numerator and denominator: proper, improper and mixed fractions, equivalent fractions Calculation: addition, multiplication and division of fractions' calculating the fraction of an amount Place value and decimal numbers: rounding; conversion between fractions and decimals; calculating with decimals Percentages: conversion between fractions, decimals and percentages; percentage of an amount; percentage increase and decrease
Algebra	Patterns and sequences; substitution; simplification; solving linear equations
Data Handling	The data handling cycle; representations of data; mean, median, mode and range; interpretation of data; probability
Shape, Space and Measures	2D and 3D shape: area and perimeter; volume; reflective and rotational symmetry; converting units of measure
Pedagogy	An introduction to the teaching of mathematics Effective teaching of mathematics Planning to teaching mathematics – statutory guidance Planning a mathematical activity
Assessment	Two in class tests on mathematical subject knowledge The design and production of a mathematics game to target a specific mathematical objectives with a group of children and a 2000 word essay to justify the approaches and evaluate the game.

Table 1.1: Introduction to Mathematics Education

The course ran for six consecutive sessions, whereby the full teaching session focussed on mathematics (full day or full evening). Attendance was not compulsory, however it was highly recommended and the teaching sessions incorporated a range of whole class teaching input, class discussion, group and individual work and consolidation activities. The strategies utilised within the teaching were intended to be consistent with the connectionist orientation whereby the teacher supports students in making links between different aspects of mathematics (Askew, Rhodes, Brown, Wiliam, & Johnson, 1997) and a blend of whole-class teaching and interactive group work (Reynolds & Muijs, 1999). Consideration was also given to the fact that these teaching strategies had appeared ‘successful’ in the past. An online learning environment was also made available to the pupils, known as BREO, and it was here that all of the teaching resources from each session could be accessed. Alongside this, self-evaluation materials were made available each week and students could attend ‘drop-in sessions’ to review any aspects of the mathematics that they were unsure of. Links were also available to online resources, in particular the BBC Bitesize revision websites for mathematics at Key Stage 3 and GCSE levels.

Although this section provides some background to the setting in which the research took place and the organisation of the mathematics unit that the students attended, further consideration with regard to the sample group who took part in this research, and the potential influence of my role, will be considered in Chapter 3.

1.4 Overview of chapters

In order to explore the research focus, the project is organised in such a way as to examine the issues regarding surrounding learning mathematics from a range of perspectives (Cohen, Manion, & Morrison, 2007; Denscombe, 2010). I was mindful that my research could not stand alone, and that there was a need to ‘scope the research topic’ in order to find out what others had said about my area of focus and to help me specify the research questions for the study (Newby, 2010). Therefore, Chapter 2 reviews a range of literature that explores the issues related to adults learning mathematics, including factors that potentially affect how people feel about this area and the implications for teachers and trainee teachers within primary education. It is within this chapter that the theme of identifying strategies to support adults in learning mathematics is considered as an area needing further exploration and the research questions are constructed as a result of reviewing the themes form the literature base.

In order to be prepared for the research process, full consideration was given to the research methodology for the study (Cohen, Manion, & Morrison, 2000), and Chapter 3 outlines this plan. The plan identifies the research framework for the study, including the research paradigm and methodological approach; the research sample; the data collection methods and the timescales for carrying out the research. Elements relating to the reliability, validity and generalisability of the project are identified, with consideration given to how the data might be analysed prior to collecting the data. In order to maintain an ethical stance, the ethics of the study are examined in light of appropriate guidelines within the institution within which I worked; those of the University of Warwick and the British Educational Research Association (BERA).

The presentation and analysis of each individual element of the research process can be found in Chapters 4, 5, 6 and 7. The research questions are returned to at the end of each chapter to identify the findings in relation to the individual aspects of data collected. Chapter 8 is the final chapter of the study and provides the opportunity to triangulate the data. It is here that the themes identified from each phase of data collection are compared and contrasted in order to answer the research questions identified in Chapter 2. Bearing in mind my commitment to 'wanting to make a difference' (Chapter 1.2), the overall research aim is returned to and a number of strategies have been identified for consideration when teaching adults mathematics. This chapter concludes with the identification of how this research has contributed to the field of mathematics education and considers the implications of the study on my own practice alongside the identification of the next steps subsequent to the end of this particular project.

1.5 Summary

This chapter has outlined the focus for the research, identifying the context in which the research took place and the structure of the project. Having now set the scene for the research study, the next chapter will explore a range of literature related to adults learning mathematics.

Chapter 2: Literature Review

2.1 Introduction

This section focuses on issues connected with adults learning mathematics and explores a range of themes within this area. The objectives of this review are to explore these themes as follows:

- To establish the existence of anxiety and negative perceptions regarding the learning of mathematics
- To identify the main factors affecting how adults feel about learning mathematics;
- To examine a potential link between teachers' and student teachers' perceptions of learning mathematics and their effectiveness in teaching the subject;
- To identify strategies that may have the potential to support adults in learning mathematics.

2.2 Mathematics anxiety and negative perceptions regarding learning mathematics

In order to examine the concept of mathematics anxiety in adults, also identified as affect (Chamberlin, 2010) it is first necessary to establish that such an issue exists, and it is not difficult to find those who have explored such a phenomenon. 'Mathephobia' is identified by Gough (1954), who examines feelings of fear and dislike of mathematics in students and suggests it is this cause of failure in mathematics classrooms which needs to be addressed. Others identify mathematics anxiety as an issue that exists for many individuals who do not necessarily suffer from other tensions, defining the concept as one which ‘involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations’ (Richardson & Suinn, 1972, p. 551). Further concerns are raised by Buxton (1981) who explores the feelings of panic that many adults face when carrying out mathematical activities identifying a negative correlation between a person’s feelings regarding learning mathematics and their mathematical development. Ashcraft and Krause (2007) extend this concern by examining the effects of mathematics anxiety has on a person’s working memory which in turn affects mathematical achievement. They suggest that preoccupation with fear and anxiety in learning mathematics takes up so much memory space that it then affects the ability to carry out mathematical problems. Others have identified similar findings whereby the ability to carry out mathematical activities is affected by emotions such as fear and anxiety (Tobias, 1993; Evans, 2002; Boaler, 2009).

Chamberlin (2010) examines a range of instruments constructed to measure affect in mathematics and concludes that the field of mathematics education has been prolific in producing a range of effective instruments to measure this construct. Richardson and Suinn (1972), suggest that a scale to measure mathematics anxiety would serve several purposes, including its use as a diagnostic tool and as a measure for rating the effectiveness of treatments. As such, they developed the ‘Mathematics Anxiety Rating Scale’ (MARS), demonstrating high significance levels for reliability and validity in measuring affect in mathematics. Fennema and Sherman (1976), in developing this work further, identify that although there are many measures that have been designed to measure ‘global anxiety’, few have been designed with dimensions that specifically relate to learning mathematics. In the construction of the Fennema-Sherman Mathematics Attitude Scale, attitudes are examined in a range of nine different aspects of mathematics, allowing for an in depth examination of mathematics anxiety and the scale has been widely utilised over a number of years (Chamberlin, 2010). Of those constructing mathematics anxiety scales, issues of reliability and validity are constantly reviewed, and most seek to construct increasingly reliable instruments, all with the aim of being able to measure mathematics anxiety in individuals (Aiken, 1974; Hopko, Mahadevan, Bare, & Hunt, 2003; Tapia & Marsh II, 2004; Pampaka & Williams, 2010). Where reliable and valid measures have been identified, it appears possible to demonstrate that the issue of affect in mathematics is a construct that exists.

It would be possible to spend further time examining different quantitative measurement scales of mathematics anxiety, but this is not the main purpose within this research. In establishing that there are a number of instruments available to support the identification of mathematics anxiety, I now turn to those who have chosen to use more qualitative instruments to establish the existence of this issue, including those who begin their discussions based on observations when teaching mathematics. Crook and Briggs (1991), when discussing the ‘baggage’ that student teachers bring into their classrooms, identify that mathematics is often associated with very strong positive or negative emotions, and that those who associate mathematics with negative emotions often try to avoid contact with the subject. Similarly Tobias (1993), as a result of her work in supporting adults in learning mathematics, suggests that for some adults anxiety may be rooted in a one-off experience that is so awful, it makes them feel that they can no longer progress further in the subject. Cornell (1999), in discussing mathematics with graduate students, indentifies mathematics anxiety as an issue for some, but also suggests that such anxiety may be possible to overcome.

In looking beyond these initial observations of adults, others examine the emotions regarding the learning of mathematics through the means of observations, case studies, questionnaires and interviews. Bibby (1999) explores a potential link between primary teachers' past histories in learning mathematics and its impact on how they feel about the subject as adults. Through in-depth interviews, she explores feelings of humiliation and disengagement in learning mathematics and in later work, identifies mathematics as an emotive subject whereby some identify feelings of 'shame' and demonstrate fear of criticism, ridicule or rejection (Bibby, 2002). Brady and Bowd (2005) explore similar emotions in adult education students, utilising a combination of Richardson and Suinn's MARS scale (1972) and open-ended questionnaire responses to establish the range of feelings behind learning mathematics. They identify fear and feelings of humiliation when carrying out mathematics and a negative correlation between mathematics anxiety and confidence in teaching mathematics.

Hembree (1990), in his meta-analysis of studies examining mathematics anxiety, establishes a correlation between high anxiety and low performance in mathematics. He also examines the effect that such anxiety might have on other mathematical experiences and establishes a correlation between mathematics anxiety and avoidance, stating that those who are anxious avoid further opportunities to study mathematics. Ma (1999) also finds that this is a particular issue in adolescents in identifying that this age is where mathematics anxiety often worsens, and that those affected tend to avoid further study in mathematics. This adds to the concerns that those choosing to study mathematics at an adult level are limited.

Having established that anxiety in learning mathematics exists for some adults and the negative effect that such anxiety may have on performance and future choices in study, I will now explore some of the potential causes behind this issue.

2.3 Factors affecting perceptions regarding learning mathematics

In examining the emotions associated with learning mathematics, it is necessary to explore the causes of such emotions, and this section aims to examine the main reasons why some adults may be anxious about learning mathematics. One of the first considerations is that of the role of the teacher.

Crook and Briggs (1991) suggest that the teacher is the overriding influence on how people feel about learning mathematics. They specifically identify issues with teachers using ‘humiliation’ to make students feel foolish in front of others, echoing the work of Bibby (1999, 2002) who states that the teacher is a key driving force in influencing, either positively or negatively, how others feel about learning mathematics. Where the influence is a negative one, being humiliated within a public context is again linked to the fear of being judged in front of others. Brady and Bowd (2005), having pinpointed similar concerns, indicate that the attitude of the instructor and the pedagogical techniques used, are the main factors affecting students’ feelings about learning mathematics. Other studies also comment on the attitude and influence of the teacher as being key factor linked to creating mathematics anxiety (Hodgen & Askew, 2006; Ashcraft & Krause, 2007; Ward-Penny, 2009; Bekdemir, 2010) and Ashcraft and Moore (2009), in particular, identify concerns over the effect of unsupportive teachers on those they teach.

Although the role of the teacher is consistently identified as a factor in how people feel about learning mathematics, other causes are considered alongside this. Bibby (1999) extends the influence of others beyond that of the teacher, identifying the potential effects of parents in influencing the emotions surrounding mathematics. This view is replicated by Evans (2002) who suggests that family backgrounds can influence how a person feels about learning mathematics, particularly if there has been success by individuals within a family subsequently putting pressure on those who feel less confident. Similarly the fear of failing in front of peers is also seen as an issue, strengthening the concerns regarding humiliation when carrying out mathematics publicly (Ashcraft & Moore, 2009; Bekdemir, 2010; Welder & Champion, 2011). Williams (DCSF, 2008), in reviewing mathematics teaching in primary settings, finds that a negative attitude to mathematics is often endorsed by parents and this again is reinforced through negative representations of mathematics in popular culture (Boaler, 2009).

When examining the factors that may affect attitudes towards learning mathematics, it is evident that the role of others, such teachers, parents and peers needs consideration. However, further studies have identified additional factors which may contribute to mathematics anxiety, and these will now be considered. One such factor potentially leading to mathematics anxiety is the transition from primary to secondary mathematics, whereby a shift in levels of understanding is seen as an issue (Crook & Briggs, 1991; Brady & Bowd, 2005; Welder & Champion, 2011). The organisation of mathematics in school may also cause problems, where the view is that being placed in the wrong set or group causes anxiety or issues in understanding (Ward-Penny, 2009; Welder & Champion, 2011) and may be one of the factors where what is identified as the ‘dropped stitch’ could arise, giving rise to the perception that missing something important can affect the whole of the learning of mathematics (Tobias, 1993, p. 60). Tobias also questions this as a reason for affecting someone’s ability to understand mathematics and compares it to other aspects of the curriculum whereby missing one or two lessons would be unlikely to have a devastating effect.

Relich (1996) acknowledges the potential effects of teachers and parents on attitudes towards mathematics, but also suggests that testing has a role to play in creating anxiety, a view shared by others (Hembree, 1990; Evans, 2002). The concern here is that stress is caused by having to carry out mathematics at speed as it creates frustration and anxiety in those who feel that they are not able to keep up (Buxton, 1981; Cornell, 1999). Alongside this there is also the perception that mathematics is an ambiguous subject which is not clearly related to reality, particularly in the classroom (Gough, 1954; Tobias, 1993; Bibby, 1999; Cornell, 1999). Boaler (2009) endorses this view, suggesting that there is a big difference between mathematics taught in the classroom and mathematics used in everyday life, and that this is something that needs to be addressed. Issues with mathematical language not being related to everyday living adds to this perception and in order to help address this it is suggested that there needs to be a move away from rote learning to the development of mathematical understanding (Haylock, 2010).

One aspect that has not been considered so far is the role that mathematics itself may have in causing anxiety. Skemp (1971) explores the nature of learning mathematics, identifying the difference between rote learning (based on memorisation of facts) and schematic learning, whereby an individual makes connections between one aspect of mathematical learning and another by developing schemas, mental structures related to mathematics. He identifies a potential conflict whereby students within classrooms may be presented with a series of rules, but struggle to find meaning as the rules become increasingly complex. In identifying that ‘understanding is not a luxury’ (p.119), he advises that if understanding of the more complex nature of mathematics decreases then anxiety increases, providing a burden so great for the student that they may be unable to develop further schemas in relating one aspect of mathematics to another.

Tall (2013) considers the work of Skemp in discussing two forms of mathematical understanding – those of instrumental and relational understanding. Skemp (1976) identifies instrumental understanding as being able to apply the correct rule within a given situation and relational understanding as being able to identify why a particular approach might be taken, hence relating one aspect of mathematics to another. Tall (2013) suggests that both of these types of understanding have a role to play in learning mathematics, but that they can also both cause anxiety when instrumental learning becomes too complex and relational understanding becomes confused. He also suggests that as students become more anxious about mathematics, they begin to avoid, or reduce effort in the subject, leading to gaps in knowledge which increases the difficulty in understanding more advanced topics. It seems that the effect of anxiety in mathematics may limit a student's ability to focus on the content of the subject itself, similar to the issues identified by others (Ashcraft and Kirk, 2001; Ashcraft and Krause, 2007).

Of the factors identified in causing mathematics anxiety so far, all relate to outside influences: the role of the teacher; other family members; the reputation of mathematics in popular culture; being placed in the wrong set; missing key lessons; carrying out mathematics in test situations; the nature of mathematics; the 'non-reality' of class based mathematics and the difficulties of understanding mathematical language. However, some raise concerns that mathematics anxiety might develop from within a person and not just be related to outside factors. One such factor that sits outside these may be the role of self-perception in learning, where a person has an in-born belief that they are just not able to carry out mathematics (Tobias, 1993). This relates to the work of Dweck (2000) who suggests that some learners are affected by a 'helpless orientated pattern of learning' whereby an individual doubts their intelligence or ability which in turn affects learning. Such learners may have developed a 'fixed mindset' where there is a belief that intelligence is fixed and nothing can change it (Dweck, 2007). Such issues can be also be identified within the finding of some of the literature explored, whereby once an individual has a certain belief regarding mathematics, in that they cannot do it, they believe that they may not be able to move forward from it (Buxton, 1981; Bibby, 1999; Bekdemir, 2010).

One final consideration in the cause of mathematics anxiety is the potential difference between genders that has been identified by some. Tobias (1978) discusses the possibility that there may be a 'male math gene' and suggests that fewer women than men enrol in mathematics courses as adults. Some, when examining differences in anxiety levels have found that mathematics anxiety is more dominant in females than males (Hembree, 1990; Hopko, et al., 2003). Jones and Smart (1995) suggest that although there is very little difference in attainment between the sexes at an advanced level, that female students tend to display lower confidence levels and are therefore less inclined to study mathematics further. Others, however, have also examined the same concept and found little difference between the sexes: Relich (1999) suggests that although there may be some differences between genders, that this is not the most dominant issue. He identifies that the factor having a greater effect on mathematics anxiety is that of high or low self concept, which he suggests is not necessarily related to gender. Similarly, Bekdemir (2010) finds little difference between male and female pre-service teachers when identifying causes of mathematics anxiety.

Whilst I acknowledge that there may be potential differences between male and female learners when faced with mathematical activities, exploration of this issue is not the main focus within this study; however, I wish to acknowledge that this may need further consideration at a later stage within this study, should gender differences arise.

Having established that mathematics anxiety exists and the potential causes of such anxiety, I shall now explore the potential effect of this on those intending to teach and those already teaching mathematics in schools.

2.4 Perceptions of learning mathematics and teaching

Thompson (1984) examines how teachers' perceptions of mathematics might influence their teaching, and concludes that although teachers' views and beliefs affect their teaching of mathematics, this relationship is complex. Ball (1990) explores this issue further by analysing the views of pre-service teachers, and discovers that the way they feel about mathematics affects their understanding and teaching of the subject and that those who teach at an elementary (primary) level are more anxious about mathematics than those teaching at secondary level. She identifies that there is a lack of conceptual understanding in connecting different areas of mathematics, and because of this there is a need to focus on the development of mathematical subject knowledge when preparing student teachers to teach mathematics. Relich (1996) establishes similar differences between those teaching at primary and secondary levels, and finds that more teachers who teach at primary level dislike mathematics. In particular those with low self-concept in mathematics identify the need to make the subject more interesting and to relate it to real life, but struggle to do so, and, similarly to Ball (1990), it is suggested that this issue needs addressing when training students to teach. Hembree (1990) adds to the body of knowledge exploring this issue and finds that the highest levels of mathematics anxiety appears in those preparing to teach at elementary level, consistent with the view that mathematics is a particularly emotional subject for generalist teachers teaching at a primary level.

In establishing that there may be issues for adults already teaching, or preparing to teach, mathematics at primary level, I will now examine the effect that this might have on their potential pupils. Brady and Bowd (2005) identify a negative correlation between mathematics anxiety and confidence to teach mathematics and imply that those who are anxious about mathematics themselves may pass this on to their students. Gresham (2007) also expresses concerns, consistent with the findings of others exploring in that those with negative views of mathematics may pass this onto their students (Bibby, 1999, 2002; Ashcraft & Moore, 2009; Bekdemir, 2010;). Haylock (2010) similarly identifies issues in adults' attitudes towards mathematics, including those of fear and anxiety, and believes that many primary teachers pass on their anxieties to those they teach.

Through the literature examined, it would seem that there is an issue regarding mathematics anxiety in student teachers and teachers, and the potential for such anxiety to be passed onto pupils. Others continue to explore this link and have established similar concerns, suggesting that this is a problem that needs addressing (Klinger, 2011a; Welder & Champion, 2011). Coben (2003) finds that although much research has been carried out into the teaching of mathematics to young students, there is little available to support the teaching of mathematics to adults. In particular the teaching of mathematics to adults within a professional role, such as teaching, is seen as a problematic area, and as such she identifies that too little research has been carried out in adult numeracy and that it is an area worthy of further work (Coben, 2006). Similar issues are identified by NIACE (2011), who advise that there is a shortage of good mathematics teachers and in particular, those involved in teacher training. Haylock (2010) too identifies the need to address mathematics teaching of adults, discussing the need to shift the perceptions of trainee teachers to become more positive, and move away from rote learning to developing mathematical understanding.

Having established a possible link between mathematics anxiety and the potential for this to pass on to others, I will now explore the work of those who have begun to address this issue.

2.5 Addressing negative perceptions of learning mathematics

In examining the potential causes of mathematics anxiety, it is possible to see that the teacher is seen as one of the main influences in affecting how others feel about mathematics. In identifying the potential tools to support adults in overcoming negative perceptions surrounding the learning of mathematics, there are those who establish the teacher of such adults as the key to managing, or overcoming anxiety. Tobias (1993) suggests that where anxiety regarding learning mathematics exists it can be addressed through discussion and collaborative working; however, she warns that there is a danger that those who are anxious and begin to manage their anxiety through support might become over-reliant on a particular teacher. She also raises a concern that mathematics anxiety is unlikely to be cured, and therefore the focus should be on managing and mastering the anxiety. Marikyan (2009) identifies the role of the teacher in being the key to support those who are anxious, and that the problem of mathematics anxiety must be acknowledged and not ignored. He suggests a range of strategies that might support adults and includes the use of student workshops, online support and peer tutoring. He establishes that it is helpful if the teacher is able to use humour within teaching and to be able to relate mathematics to real life situation. Welder and Champion (2011) also identify the teacher as being a key factor in overcoming mathematics anxiety, and identify the need for experienced teachers to teach mathematics education to adults. They suggest that the use of small group work and practical resources contributes to the development of primary teachers of mathematics.

Although Dweck (2000, 2007) identifies self-perception as a potential ‘block’ to learning, she also identifies the teacher as key to supporting those affected in moving on. When discussing how to support those who feel helpless in learning, she identifies the need for the teacher to support students in identifying what the possibilities for learning might be. She explores the belief that mindsets can be altered and that a person with a fixed mindset can be encouraged to believe that they can change their achievements (Dweck, 2007). She identifies strategies that teachers might use in their teaching, and similarly to Marikyan (2009), suggests that it is not necessary to hide that something may be challenging, but that it is possible to play a positive role in acknowledging this and demonstrating a desire to help students overcome challenges faced. Dweck states that teachers should create a nurturing atmosphere where there is an expectation of high standards and states that ‘growth minded teachers tell their students the truth and give them the tools to close the gap’ (Dweck, 2007, p. 199).

Johnston-Wilder and Lee (2010b) also examine the tools that might be used to change how learning mathematics is perceived, and identify the term ‘mathematical resilience’ as an approach where the learner is able to continue in their learning of mathematics despite setbacks and challenges on the way. Their approach is based on based on learners building understanding and confidence together, whereby mathematical resilience is likely to be fostered when mathematics is seen as a social construct, within a community of peers and adults interacting. Further exploration of this concept demonstrates success through the use of active ways of collaborative learning, encouraging students to make videos of mathematical concepts by working together (Johnston-Wilder & Lee, 2010a).

When examining the tools identified for working with those who are anxious regarding the learning of mathematics, strategies are identified which sit within social constructivist principles. Vygotsky (1978) discusses the importance of social activity within learning, and that interaction with others 'awakens a variety of internal development processes' (Vygotsky, 1978, p. 90). His principles stress the need for social interaction to support learning. Wittgenstein (1978) develops these principles within a mathematical context, suggesting that mathematical language only has meaning when it is used, and that mathematical understanding evolves as part of linguistic and social activity. Others, who examine the need to address mathematics anxiety, also identify the use of social interaction within their work:
Gresham (2007) suggests that a constructivist approach to learning mathematics may be utilised in supporting adults in overcoming mathematics anxiety. Methods identified are based on discussion, journal writing, directed group activities and presentations, and students within his research demonstrate a statistically significant drop in levels of mathematics anxiety. Similarly, Ashun and Reinink (2009) explore how the confidence of pre-service teachers in learning mathematics can be developed and state that a constructivist approach to learning and teaching mathematics may be the approach that is needed when teaching mathematics to adults. Skemp (1989) also identifies the need to support learners, and that the role of discussion forms part of this process.

Klinger (2011b), however, suggests that social constructivism is not the only approach to be considered, and identifies the role of 'connectivism' as a way to help adults overcome mathematics anxiety. He suggests that, 'The aim is to establish, wherever possible, connections between what students already know and that which they seek to learn' (Klinger, 2011b, pp. 16,17). This could be considered in light of the work of Skemp (1971), discussed earlier, who identifies the need for the development of ‘schema’ in the learning of mathematics, whereby an individual makes connections between one aspect of learning and another, developing concepts by building on what is already known.

Further to this, Skemp (1989) expands on the role of the teacher plays on teaching mathematics, identifying that they need to be clear in understanding and communicating mathematical principles to learners. He identifies a three step this: Firstly, the need to build on students’ direct experiences, which allows the formation of mental models (experience and experimenting); secondly, the need for discussion to develop an understanding of the areas of focus (communication and discussion); and, thirdly, the development of new knowledge from existing knowledge (creativity and internal consistency). He suggests that when a teacher provides opportunity for the three steps to be used in combination, this is a powerful approach to teaching mathematics.

Expanding on the skills that a teacher needs to teach effectively, Shulman (1986) identifies that three forms of knowledge for teaching are needed: content knowledge, whereby a teacher has the appropriate subject knowledge understanding for what they are to teach; pedagogical content knowledge, where a teacher understands how to approach the teaching of the subject in hand and make it accessible to learners; and curricular knowledge in understanding the expectations set within a given curriculum and the materials needed to teach within it. In support of this, Rowland, Turner, Thwaites and Huckstep (2009) suggest that teachers need to have a clear understanding of both subject knowledge and pedagogical knowledge in order to teach the subject well. They also advise that there is a need for teachers to have a ‘profound and connected understanding’ of mathematics (p.23), similar to those discussed earlier who identify that connections need to be made between one aspect of mathematics and another.

Having considered how mathematics teaching might be approached in order to address mathematics anxiety, a final consideration in this section is related more specifically to adult learners.

2.6 Adult Learners

I have already drawn attention to the issue that although much research has been carried out into pupils learning mathematics, less has been carried out in relation to adults learning mathematics (Coben, 2003); however, some parallels may be drawn with others who have examined the role of the connectionist teacher in supporting pupils in learning mathematics successfully (Askew, Rhodes, Brown, Wiliam, & Johnson, 1997) and the need to develop such connections in adults. In examining the work of those who have researched theories of adult learning theory, known as andragogy, it may be possible to establish further links between these considerations and those who have identified potential theories for addressing mathematics anxiety in adults.

Knowles developed his theories of adult learning, building on the work of Lindeman (1926), establishing a difference between adult education, known as andragogy, and conventional education of youths, known as pedagogy. He offers an andragogical model for adult learning, seen in Table 2.1, built on six assumptions of pedagogical learning (Knowles, Holton III, & Swanson, 2005):

The need to know	Adults need to know why they need to learn something before undertaking learning.
The learner's self concept	Adults need to be responsible for making their own decisions.
The role of experience	Adults' prior experiences affect learning and these need to be recognised.
Readiness to learn	Adults need to be ready to move from one stage of developmental learning to the next.
Orientation to learning	Learning needs to be life-centred in order to support adults in dealing with specific situations and tasks. Links are made to real life.
Motivation	Adults may be motivated by external and internal forces.

Table 2.1: Summary of Knowles' six assumptions for adult learning

In identifying these assumptions, Knowles (2005) continues to examine how adult learners' needs might be addressed and suggests that adults need to be prepared for the learning process, rather than just a content orientated approach. He suggests that this might be supported through the use of constructivist type approaches such as group discussion, simulation and problem solving activities, within an atmosphere conducive to learning. As in the work of Klinger (2011b) he identifies the need for learners to make connections between one aspect of learning and another, and echoes the views of those who have established the existence of similar approaches with younger students (Skemp, 1971; Askew et al, 1997).

Harper and Ross (p.166, 2011) examine the application of Knowles' learning theories to adult learners on an undergraduate degree programme. In doing so, they have identified similarities between their findings and those of Knowles (note that the links to Knowles' theories have been added for clarification):

- Students like having an end in sight (the need to know)
- Students like being in charge of their learning (the learner's self concept)
- Students do better when they are actively engaged in their learning and understand where it is leading (the role of experience and orientation to learning)
- Students enjoy education (motivation)

Hegarty (2011) also considers the motivation behind adult learners returning to education, and similarly finds that there is a need to make learning relevant to the experience of adults, suggesting that group work and problem solving approaches may be tools that the teachers of such adults may use. He also stresses the need for the teachers to be if the highest quality, with a good understanding of their field. Further to this, Woodson Day, Lovato, Tull and Ross-Gordon (2011) explore the needs of a range of adult learners and again stress the need for learning to build on prior experience through the use of active participation of learners within well-structured teaching sessions. Others have identified similar considerations in relation to the difference between adult learners (Walkin, 2000; ; J. Rogers, 2001; A. Rogers, 2002).

In considering how mathematics anxiety in adults might be addressed, it appears that there are a number of factors to consider; including the needs of adult learners alongside the challenges of overcoming anxiety and negative perceptions within learning mathematics. In particular, the role of the teacher is consistently identified as having a key role to play in the learning of mathematics, and the strategies used within such teaching need further consideration. Exploring these issues will form the basis for my research, in order to identify potential factors that may support adults in developing a more positive perception regarding the learning of mathematics.

2.7 Summary

In concluding this review of literature, I shall now draw together the key findings, and link these to the research questions to be considered. Four key themes are identified for consideration:

Firstly, by examining the work of those who have focussed on using quantitative methods to measure levels of anxiety, it has been possible to establish that mathematics anxiety exists for some adults (Richardson & Suinn, 1972; Aiken, 1974; Fennema & Sherman, 1976; Tobias, 1993; Hopko, et al., 2003; Tapia & Marsh II, 2004; Pampaka & Williams, 2010). This is further reinforced by others who have used more qualitative approaches to identify negative perceptions regarding the learning of mathematics through informal observations (Gough, 1954; Buxton, 1981; Crook & Briggs, 1991; Tobias, 1993) or through interviews, questionnaires and observations (Bibby, 1999, 2002; Brady & Bowd, 2005). Others confirm these views through examining a range of studies within this field (Hembree, 1990; Ma, 1999; Chamberlin, 2010).

Secondly, a number of causes of negative perceptions related to mathematics can be identified, with a consistent identification of the effect of the teacher in influencing how people may feel in regards to learning mathematics (Hodgen & Askew, 2006; Ashcraft & Krause, 2007; Bekdemir, 2010). Other factors are also considered, and those identified most consistently include the influences of others, including parents and peers (Evans, 2002; Ashcraft & Moore, 2009; Welder & Champion, 2011); transition and setting arrangements (Crook & Briggs, 1991; Brady & Bowd, 2005); the lack of connections between mathematics and reality (Tobias, 1993; Cornell, 1999; Bibby, 1999; Boaler, 2009), and the speed at which mathematics is expected to be carried out (Hembree, 1990; Evans, 2002). The nature of mathematics itself is also considered as a potential cause of anxiety (Skemp, 1971 and 1976; Tall (2013). One final suggestion regarding the cause of anxiety in learning mathematics is related to personal perceptions limiting a person's ability to carry out mathematics (Bekdemir, 2010; Buxton, 1981; Dweck, 2007; Tobias, 1993).

Thirdly, it has been possible to establish a potential connection between those who are anxious about mathematics and the effect on their teaching. This appears to be a particular issue for those teaching at primary level, whereby more teachers display mathematics anxiety than those teaching at secondary level (Ball, 1990; Hembree, 1990; Relich, 1996). The issue here is not just that negative perceptions regarding learning mathematics exists within primary education, but that those who are anxious may in turn pass this onto their pupils (Brady & Bowd, 2005; Gresham, 2007; Ashcraft & Moore, 2009; Bekdemir, 2010; Haylock, 2010).

The final theme is the consideration of how adults might be supported in learning mathematics, identified by Coben (2006), Haylock (2010) and NIACE (2011) as an issue that needs to be addressed. Of those exploring this area, some identify the specific needs of adult learning, including the need to relate learning to real life and to understand why something needs to be learned (Lindeman, 1926; Knowles, et al., 2005; Hegarty, 2011; Harper and Ross, 2011); however, of those who have examined mathematics anxiety in adults, there have been consistencies in identifying approaches that might support adults overcoming their fears. This includes those who suggest that a constructivist approach might be appropriate, including the use of collaborative learning and group work (Gresham, 2007; Ashun & Reinink, 2009; Johnston-Wilder & Lee, 2010b), closely linked to the theories of Vygotsky (1978) and Wittgenstein (1978). Others suggest that a connectivist approach may be more beneficial, whereby adults are encouraged to make connections between one aspect of mathematics and another (Askew, et al., 1997; Klinger, 2011b). Whatever approach is identified, the role of the teacher is consistently identified as a key factor in influencing learning in mathematics, and certain characteristics such as being approachable, knowledgeable in mathematics and able to use a range of teaching approaches are seen as necessary (Tobias, 1993; Marikyan, 2009; Johnston-Wilder & Lee, 2010a; Welder & Champion, 2011).

To examine these themes further, the aim of this study is to explore adults' perceptions in identifying strategies to support them in learning mathematics as they embark on an undergraduate degree course in Applied Education Studies. In order to do this, the following research questions have been identified:

- What perceptions do students have regarding learning mathematics before embarking on their first mathematics education course?
- What past factors have affected students' perceptions of learning mathematics?
- Is there a change in the students' perceptions of learning mathematics after their first undergraduate mathematics education course?
- What factors are identified that affect how a student feels about learning mathematics as an undergraduate?
- Are there any perceived strategies that might support students in learning mathematics?

Having explored a range of literature and identified the associated research questions, the next chapter will discuss the methodological approach chosen for the study.

Chapter 3: Methodology

3.1 Introduction

In the previous section I identified the research aim and questions to be examined within this study, and I will now focus on the identification of an appropriate research design to guide the different phases of my project. Robson (2011) suggests that unless proper consideration is given to the design of a research project, it is likely that the researcher will end up with 'a mess' (p.5), something which I was keen to avoid! In order to carry out the practicalities of the research, I needed to establish the feasibility of my project and then proceed to the research design and methodology phase to create an appropriate plan for carrying out the research (Cohen, Manion, & Morrison, 2000). Newby (2010), states that '*Research methodology* is concerned with the assembly of research tools and the application of appropriate research rules' (p.51) and with this in mind, this section focuses on establishing an appropriate methodology.

The objectives for this section are as follows:

- To establish the context for the research.
- To identify the research framework, including the research paradigm and methodological approach.
- To identify and justify the methods chosen to answer the research questions
- To consider issues regarding reliability, validity and generalisability
- To identify the approaches taken to analysing the data
- To consider the ethics of the research project
- To establish the timescales for the research

3.2 Context

I have already established that negative perceptions in learning mathematics exists for some adults, exhibited in a number of ways including through feelings of panic, shame and frustration (Buxton, 1981; Tobias, 1993; Bibby, 2002; Boaler, 2009). Within the context of my own background where I have been teaching mathematics to both children and adults since 1985, this is consistent with some of the concerns raised by those whom I have taught. Since 1999, however, I have worked mainly with adults in primary mathematics education: firstly as a consultant leading in-service courses and school-based support for qualified teachers, and secondly in my current role, since 2006, as a senior lecturer on a BA Applied Education Studies course at a university within the east of England. On this course I teach mathematics education to part-time undergraduate students and it was a sample of these students who were the focus of the study. Detail regarding the background to the course has already been discussed in Chapter 1.3, and also on the organisation of the first year mathematics unit, so it is the detail of these students that will be identified here.

Having established a potential link between adult anxieties regarding learning mathematics and the possibility that these may be passed on to children (Brady & Bowd, 2005; Gresham, 2007; Ashcraft & Moore, 2009; Bekdemir, 2010; Haylock, 2010), I was keen to explore this issue further. I wanted to see if students displaying negative perceptions could be supported in their development in learning mathematics, and if so, what the strategies were that might be identified to help them. In order to do this, I needed to identify a sample of students for my study from the research population of all BA Applied Education Studies students (approximately 240 students), and examine the views of those who may go through a period of change from starting the course to completing their first taught mathematics unit as undergraduates. As such, this led me to identify the first year undergraduate students as a purposive sample, whereby the students met the criteria I identified (Cohen, et al., 2000; Creswell & Piano Clark, 2011; Robson, 2011) and hence the aim of my research was established:

> To explore adults' perceptions in identifying strategies to support them in learning mathematics as they embark on an undergraduate degree course in Applied Education Studies

The sample of students chosen for the study included a total of 75 undergraduate students combining the 2011/12 Year 1 day (34 students) and evening (41 students) cohorts. This allowed me to gain the perceptions of a larger sample of students in terms of their views of learning mathematics, but also provided me with the opportunity to identify from this a smaller sample group who demonstrated specific behaviours within the full sample, defined by Newby (2010) as specialist group sampling. I will return to how this sub-group was established later when discussing the methods utilised within this research.

In order to focus in on my research title, five research questions were established based on my personal observations within my teaching and by examining the literature reviewed within the field of mathematics anxiety. Consideration was given as to how the sample groups might support the exploration of these questions, coded below as RQ1 for Research Question 1, and so on:

- What perceptions do students have regarding learning mathematics before embarking on their first mathematics education course? (RQ1)
- What past factors have affected students' perceptions of learning mathematics? (RQ2)
- Is there a change in the students' perceptions of learning mathematics after their first undergraduate mathematics education course? (RQ3)
- What factors are identified that affect how a student feels about learning mathematics as an undergraduate? (RQ4)
- Are there any perceived strategies that might support students in learning mathematics? (RQ5)

For the purpose of exploring the research questions, the samples were utilised as follows, with the specialist sample group identified to probe more deeply into the findings of the full sample group (see Table 3.1):

Research Question	**Full sample group**	**Specialist sample group**
1	✓	X
2	✓	X
3	✓	X
4	✓ (initial findings)	✓ (in depth)
5	✓ (initial findings)	✓ (in depth)

Table 3.1: Sample group distribution

3.3 Research Framework

The next step was to consider my philosophy behind conducting this research and the conceptual framework within which I proposed to operate (Hartas, 2010a). In examining the paths for progression in planning research as identified by a number of authors, (Hartas, 2010e; Newby, 2010; Creswell & Piano Clark, 2011; Robson, 2011), common themes became apparent, and using these I decided to frame my plans within the following progression (Table 3.2):

Research questions ↓ Research paradigm ↓ Methodological approach ↓ Research methods

Table 3.2: Four levels of developing a research study

(adapted from Creswell and Piano Clark (2011) and Hartas (2010e))

Bryman (2007) suggests that the conventional view within methodological discussions is that the research question(s) should guide the choices a researcher makes in designing and choosing research methods, although he questions whether or not this is what always happens in practice. Collins and O' Cathain (2009) and Niglas (2009), in identifying the considerations a novice researcher should be aware of when planning research, similarly advise that research questions should drive the choice of methods. As such, my research questions were rooted in practical matters guided by my prior experiences in observing students' anxiety in learning mathematics and constructed in order for me to clearly establish the problem I wanted to address (Robson, 2011).

Having established my research questions, I considered the research paradigm within which my own philosophies sat. Hartas (2010b) suggests that within educational research, reference should be made to a range of paradigms as appropriate to the focus of study. Similarly Cohen, Manion and Morrison (2007) stress the importance of using appropriate methods to explore a research question whereby both normative and interpretive approaches may complement each other, suggesting a potential for combining the use of both quantitative and qualitative data. These views aligned with my beliefs which are focussed within identifying the most appropriate tools for exploring a problem based in the real world, and the philosophy identified behind such a view is that of pragmatism (Feilzer, 2009; Denscombe, 2010; Robson, 2011). Feilzer (2009) implies that pragmatism is useful in allowing researchers to explore a world created of different layers, some which may be subjective, some objective, or a mixture of the two, opening the way to considering the use of a mixed methods approach to research. She suggests that this approach may lead the way to abductive reasoning, where logical connections are made between different types of data, moving between both inductive and deductive thinking. Denscombe (2008) similarly advises that pragmatism allows for flexibility within modern research, underpinning the justification for the use of mixed methods. As my research was to focus on a problem set within the real world, and contained several layers identified within the research questions, I was mindful of Coben's (2003) view that a mixed methods approach combining the use of both qualitative and quantitative methods might be appropriate in exploring issues related to adults learning mathematics.

In considering a mixed methods approach I was 'free to use all possible methods to address a research problem' (Creswell & Piano Clark, 2011, p. 13). Despite the views of those suggesting that mixed methods research has the potential to provide breadth and depth to a study whereby the use of one method might be complemented by another (Burke Johnson, Onwuegbuzie, & Turner, 2007; Denscombe, 2010; Newby, 2010; Robson, 2011), I was mindful of concerns that I would need to have a good understanding on how to mix methods to produce credible research (Onwuegbuzie & Leech, 2009). Bryman (2006), in reviewing studies using mixed methods approaches, suggests that researchers do not always align their research methods to their research questions, and therefore I needed to maintain my research focus and be sure that using a mix of methods would offer advantages that just one method would not.

Another challenge that I had to consider was in identifying the mixed methods design that I was going to use, and Niglas (2009) refers to a range of typologies that might support a researcher in identifying a plan for mixed methods research. When exploring these typologies, I was able to identify a consistency within two types of research design, those planning to use concurrent methods (simultaneous) and those planning to use sequential methods (Leech & Onwuegbuzie, 2009; Denscombe, 2010; Creswell & Piano Clark, 2011; Robson, 2011). As I planned to track my sample of students through their first year as undergraduates, and I was dependent on a sequence of events, I believed my design to be a sequential one. In referring to Table 3.1, my plan was first to collect data from the full sample for all five research questions, and due to the size of the sample, this was likely to be quantitative data; secondly, the findings would be explored in more depth for questions four and five with the specialist sample group, likely to be qualitative data. This is consistent with the 'explanatory sequential design' identified by Creswell and Piano Clark (2011, p. 81) who suggest that the overall purpose of such a design is to use qualitative methods to explain quantitative results. However, I did not want to rule out the possibility of combining the two methods at any one point, as I had already decided that I wanted the freedom to use a range of approaches for the research questions in hand. As such, I did not discount the possibility of using a more embedded design, whereby 'quantitative and qualitative approaches are combined and embedded within a traditional design or procedure' (Creswell & Piano Clark, 2011, p. 91), a combination similarly identified by Leech & Onwuegbuzie

(2009). This led me to the fourth step in my planning process, to identify the detail of my proposed research methods.

3.4 Research Methods

Onwuegbuzie & Leech (2009) advise that exemplar studies using mixed method approaches should be available to researchers to support them in deciding on how they might mix their methods, expressing a view similar to that of Creswell and Piano Clark (2011) who suggest that there is a need to explore a range of studies in order to understand the effect of mixed methods on research. Within the literature review discussed earlier, I found a number of studies that used a solely qualitative approach (Bibby, 2002; Evans, 2002; Hodgen & Askew, 2006) or a solely quantitative approach (Richardson & Suinn, 1972; Aiken, 1974; Fennema & Sherman, 1976), but that the studies which combined both approaches to support their research questions aimed to use a combination of methods to probe more deeply into initial findings, which was consistent with my rationale for using a mixed methods approach (Nardi & Steward, 2003; Ashun & Reinink, 2009; Bekdemir, 2010;). This led me to utilise the following methods:

3.4.1 Examination of existing data

In order for me to establish greater detail regarding the context of the sample group and information regarding their background, I used existing datasets to provide me with information I needed. Muijs (2011) suggests that such datasets can be used to support researchers in exploring particular research questions, and I believed that I needed to know the starting points of the students on the course in order to explore their development as they progressed through their first year of undergraduate study. In this case I had access to two strands of data:

- Strand 1 (May 2011): Group statistics collected by the University administration team to include mode of attendance (day or evening), date of birth, gender, ethnicity, identification of special needs and highest mathematics qualification.

- Strand 2 (June 2011): An initial audit of students' mathematical skills on entry to the course, where students completed questions based on subject knowledge within the National Curriculum attainment target strands of number and algebra, shape, space and measures and data handling (DfEE & QCA, 1999). These audits were marked and reviewed with the students and used to inform the content of teaching sessions in their first year. Alongside this, a percentage score to demonstrate their attainment from the audit was calculated (Appendix B).

  Students were also asked to complete their perceived confidence levels using a Likert type scale adapted to a 10 point scale to allow for ease of analysis (Robson, 2011). In this case, 0 was identified as 'not confident', 5 as 'reasonably confident' and 10 as 'very confident'. Hartas (2010b) suggests that data presented in numerical form is suitable for mathematical analysis and in this case it would enable an analysis of the ranges of student attainment and confidence and potential correlations between these variables at the start of their degree course.

  The final aspect of the audit gave the students the opportunity to identify anything they wished to be known at this point regarding their mathematical ability, allowing me to identify any initial perceptions that the students might have regarding learning mathematics (RQ1 and RQ2).

3.4.2 Survey Research

All of my research questions were designed to examine the students' perceptions of learning mathematics as they progressed through their first year of undergraduate study and led me to consider Robson's (2011) view that survey research might be suitable for examining the characteristics of people and in exploring relationships between such characteristics. I also examined Denscombe's (2010) three step consideration for the use of survey research; Firstly, that it is beneficial when aiming to gather 'wide and inclusive coverage' in this case the whole of the Year 1 student cohort; secondly, when information is needed 'at a specific point in time', required by my research as the students would need approaching during particular times during the year and, finally, 'for empirical research', whereby I intended to examine students' personal perspectives of their experiences. As this appeared to align with my intended focus I considered that the use of survey research to explore the students' perceptions would be appropriate; however, I needed to make a decision regarding the type of survey research I intended to carry out.

In examining the range of survey methods that were available to me, these most frequently fell into two categories, the face to face interview and the questionnaire (Cohen, et al., 2007; Hartas, 2010d; Robson, 2011). This was consistent with the most common methods utilised in mixed methods research on mathematics anxiety and affect discussed earlier. With a sample size of 75 students, I decided that the most efficient way of gaining initial perceptions would be to administer a questionnaire (Sharp, 2009) and this would allow me to focus on my first two research questions, examining students' perceptions of learning mathematics before they started their first mathematics unit as undergraduates (RQ1), and their perceptions regarding the past factors affecting them in learning mathematics

(RQ2). I was mindful that my research questions and tools needed to be closely aligned, and therefore constructed my questionnaire with these at the forefront.

The questionnaire consisted of six questions (Appendix C), and was administered in November 2011, at the end of the term prior to the students attending their first mathematics unit. Question one was constructed following an analysis of the students' mathematics audits and was designed to gain a quick overview of how the students felt about learning mathematics at a specific point in time (RQ1). Questions two and three were constructed using Likert type scales and were designed to examine potential links between perceived confidence and perceived understanding in learning mathematics (RQ1). Questions four and five were designed to explore the students' past experiences in learning mathematics, and were in the main closed questions were the respondents were given a number of possible choices to respond to (RQ2). These choices were identified from the most common factors affecting how adults perceive learning mathematics identified within the literature reviewed in section 2. I was aware that in providing closed questions that I may have limited the respondents' choices, a disadvantage identified by Muijs (2011) He suggests that to overcome this, open questions can be used to discover opinions that had not been considered previously. I therefore included a qualitative element to the questionnaire, where the students were asked to describe an experience that had affected how they felt about learning mathematics (RQ2).

The second set of data could not be collected until the students had completed their first mathematics education unit as undergraduates, which I taught, and this took place over a six week period in January/February 2012. As I wanted to maintain the size of my sample at this point, I was able to justify the use of a follow up questionnaire to establish any changes in the students' perceptions of learning mathematics (RQ3), if there were any strategies that were identified that affected how they felt about learning mathematics (RQ4) and if there were any perceived strategies that might support students in overcoming mathematics anxiety (RQ5). The questionnaire consisted of seven questions and was administered at the end of the final teaching session in February 2012 (Appendix D). The first three questions were exactly the same as those on the pre-teaching questionnaire in order to establish, by direct comparison, any changes in the students' perceptions of learning mathematics after their first mathematics unit as undergraduates (RQ3). I wanted to extend this further to explore whether or not the students perceived any changes in their levels of understanding and confidence, allowing me a comparison within the questionnaire itself, and questions four and five explored this area (RQ3). Question six focussed on the factors that may have affected how the students felt about learning mathematics (RQ4 and 5), and the choices given were identified through the themes explored within the literature review and personal knowledge of what was made available to the students during the unit. Originally I considered a three point scale of positive, negative or no influence here, but I wanted to be able to rate the factors in order of perceived importance, and so maintained continuity with m use of the five-point Likert scale. As in the pre-teaching questionnaire, I did not want to limit the students' choices, so question seven was designed to expand on their views of any factors that may have affected how they felt about learning mathematics over their first course as undergraduates (RQ4 and 5).

Having used a mainly quantitative approach to the first steps of my research, with some embedding of qualitative measures, I wanted to explore, in more detail the results of the questionnaires, consistent with the rationale provided by Creswell and Piano Clark (2011) for using an explanatory design to research. I therefore needed to identify the specialist sample group from whom I could explore the results further and to do this, I aimed to establish a sample of students for whom some form of change had taken place since embarking on their degree course. Since all of the questionnaires were anonymous, I looked to the other measures I had available that might support me in doing this and considered comparing the results of the mathematics audit completed in June 2011 and the results of the mathematics tests associated with their first unit, taken in March 2012 (Sample items, Appendix E). I was aware that as the audit and the test were not identical, I would need to establish a similarity that would allow me to identify a potential measure of progress. Hence I examined the concepts that were explored within both methods (Appendix U) and established that of the 19 concepts explored within the audit, 16 of these were also tested at the end of the unit. Although this was not an ideal match, it provided me with a measure that I could consider in terms of rates of progress between the audit and the unit test.

Using the audit and tests scores, I aimed to identify those students whose scores had increased the most during this period of time. My rationale behind this was rooted in the links made within the literature review on the potential correlation between low levels of confidence and performance in mathematics, and was consistent with the findings of a pilot study, where a positive correlation between confidence levels and mathematics scores was identified (Wicks, 2011). It was possible, therefore, to consider that those students making the greatest rates of progress may potentially have felt more confident, or less anxious, in learning mathematics during their first mathematics education unit, and it was these students I wished to focus on.

In order to identify those students who had made the greatest progress in terms of attainment scores, I looked for a subset of students who might provide an appropriate size sample. I planned to carry out focus group discussions, whereby small groups of people are brought together to discuss a specific topic (Denscombe, 2010). My aim was to facilitate, rather than lead discussion, as I was aware that in talking about mathematics, emotive issues might be raised and the participants could be supported by other members within the group (Robson, 2011). I did consider individual interviews, but was also aware that there was a possibility of me as the researcher, and also as the teacher, influencing the views of the person interviewed and that a group situation may take the focus off any one individual (Cohen, et al., 2000; Hobson & Townsend, 2010). In terms of guidance regarding the size of focus groups, optimal sizes vary from six to twelve participants (Denscombe, 2010; Robson, 2011), so I aimed to invite a larger sample of students to be involved in focus group discussions to then allow for the fact that it was unlikely that all invited students would want to be involved. With that in mind, I invited the students who had made a greater rate of progress than the median scores for each of the day and evening group, which led to twelve volunteers from the sample; however, only ten of the students were available for focus group discussions, and hence three focus groups took place in June 2012, comprising of two groups of four students and one pair. Further detail relating to the specific construction of this sample is discussed in Chapter 7.

In order to probe more deeply into the students' perceptions of learning mathematics identified within the post-teaching questionnaires, these were first analysed in order to identify the areas for further exploration within the focus group discussions. Activities were designed to encourage the students to talk with each other on a specified area, and to provide a focus so that I could be a facilitator within the discussions (Appendix F). The first activity was designed to identify the students' perceptions of learning mathematics on the day of their focus group discussion, and was based on question one of the questionnaires where the students identified words which explained how they felt about mathematics RQ3). Activity two aimed to explore further the factors identified within question six of the post teaching questionnaire, and was designed to probe more deeply into the factors that might have influenced their learning during their first mathematics unit (RQ4 and RQ5). The third activity aimed to explore the one factor identified as an influence in learning mathematics by all students (the teaching), to probe more deeply into why this might be so and to identify the characteristics that might be identified within this area (RQ4 and RQ5). The final activity probed more deeply into the other factors identified within the questionnaire as affecting how students felt about learning mathematics (RQ4 and RQ5).

3.5 Validity, Reliability and Generalisability

In identifying my research methods, I had to keep in mind the issues surrounding validity and reliability as it is suggested that these can be a potential threat to the researcher, not only in the identification of methods, but also in the analysis of the data collected (Cohen, et al., 2007). In terms of validity, I needed to aim to ensure that my methods actually measured what they were supposed to measure (Connolly, 2007; Thomas, 2009; Bell, 2010) and my first step in doing this was to align my research questions closely with those asked within the questionnaires given to the participants, so that I did not veer away from my focus. I was also careful to identify a purposive sample for the research, as Cohen et al (2007) suggest that this can also be a threat to the validity of a study. In terms of the qualitative aspects of the research, the focus was on presenting an accurate view of the participants' views (Creswell & Piano Clark, 2011) and to do this I planned to identify my methods of analysis in advance to maintain a focus on the research questions identified (see Section 3.6, Approaches to Analysis). Of particular concern to me was the content validity of the study, to make sure that the content was focussed on what I aimed to find out and to support this process I made used of the literature reviewed within my area of focus to help me structure my questions (Muijs, 2011). I also referred to my supervisor and colleagues within the field of education to consider face validity in judging whether or not the instruments would measure what they were planned to measure (Robson, 2011) .

In terms of reliability I needed to consider the ‘trustworthiness’ of my measures in providing consistency over time (Connolly, 2007). It is advised that the use of poorly worded questions and ambiguous language are threats to reliability, and these were considered in the construction of the questionnaires and those posed within the focus groups (Connolly, 2007; Baumfield, Hall, & Wall, 2013). I could not discount that some of the words used within the questionnaire may be subject to personal interpretation, and I was particularly concerned with the use of the word ‘confidence’; hence, in order to try to minimise the effect of this, a definition of this term was constructed from dictionary definitions (Soanes and Stevenson,2009; Smith, 1998). With regard to the qualitative aspects of the study, I was aware that clear measures were needed to support the process of consistency in interpretation in using the methods of analysis identified. Muijs (2011) suggests that one way of doing this is to have more than one person look at the same data and to agree on findings and themes together, known as inter-rater reliability, and this was planned into my data analysis process.

In order to improve the validity and reliability of my research, I planned to triangulate my data, defined by Cohen et al (2000) as the ‘use of two or more methods of data collection in the study of some aspect of human behaviour’ (p.112). In using more than one method to explore each research question, I was able to corroborate or question my findings by comparing the data produced (Denscombe, 2010). A summary of the distribution of the research questions within the research methods is identified in 3.3 below, and demonstrates how each research question was explored within two aspects of the data collection process.

	Audit	Pre-teaching questionnaire	Post teaching questionnaire	Focus group discussions
RQ1	✓	✓		
RQ2	✓	✓		
RQ3			✓	✓
RQ4			✓	✓
RQ5			✓	✓

Table 3.3: Triangulation of research methods

In terms of my own role as practitioner-researcher, I could not rule out my role as the students' teacher in potentially biasing their responses. Creswell and Piano-Clark (2011) advise that the researcher must disclose their dual role to participants and this was done right at the start of the research and also within each phase. Baumfield et al (2013) suggest that there is a difficult balance to be made between these two roles and that potential bias can be minimised within the analysis phase. Through triangulating my results and planning my research against clear research questions, I aimed to minimise my personal bias, but I could not discount the fact that participants may respond in the way I might want them to respond in order to please me as their teacher, as my dual role had the potential to impinge on my them (BERA, 2011). In order to help address this issue, I looked to identify additional tools that might support me, in particular in relation to percieved levels of confidence and understanding and turned to the end of unit tests that all students were required to take, and were used to identify the specialist sample group. As a result of this, I was able to compare rates of progress between the audit and test scores and to identify whether or not the students perceptions regarding their understanding were reflected in their rates of progress. Having already identified a correlation between confidence and understanding, I was able to similarly explore the same concern in relation to students' perceptions related to confidence.

In an effort to ensure that my questions were clear and unambiguous it is advised that where possible, research methods are piloted by a similarly structured group to the research sample (Muijs, 2011; Robson, 2011). The first year cohort from 2010/11 piloted all methods and feedback was gained on the clarity of the questions and whether or not the participants felt that they asked what was intended. This was particularly useful with the focus group discussions and activities, as this was my area of least experience.

With regards to generalisability, Muijs (2011), suggests that researchers are likely to want to relate their findings to the wider population; however, some note that this is potentially challenging within education. Some identify difficulties in generalising from educational research as each research setting brings with it a number of variables that may not be applicable in other settings (Hillage, Pearson, Anderson, & Tamkin, 1998; Bassey, 2001; Gorard, 2002). In deciding to use a purposive sample for my research, I am aware that in terms of generalisation, the results of this research may only be applicable to the participants identified (Hartas, 2010c); however, Bassey (1981) suggests linking similar studies may allow a researcher to combine findings with other research to support the process of generalisation. Having examined other studies within the field of mathematics anxiety, I plan to compare those findings with mine and therefore consider the possibility that the findings may be transferable to the wider body of knowledge within this area (Denscombe, 2010). In being rigorous with my design quality and analysis, my aim is that this will support the process of generalisation (Collins & O'Cathain, 2009).

3.6 Approaches to Analysis

In terms of the data collected, as I had taken a mixed methods approach to my research, this produced both quantitative and qualitative data. In my quest to produce credible research, as identified earlier, I needed to consider the specific analysis of each approach in order to gain a better understanding of my research aim (Denscombe, 2010). In order to do this, I categorised the data and considered the specifics of my analysis for each aspect (Table 3.4). It is to be noted here that although elements of the research questions contained data regarding opinion and feelings, these questions were constructed for respondents to answer in a quantitative way, an approach that may allow data collection on a wide range of phenomena in a manageable form (Muijs, 2011), with the qualitative elements of the study designed to probe more deeply and aid validity to the study.

Quantitative Data	**Qualitative Data**
Group statistics	
Audit: scores and confidence levels	Audit: Students' personal statements regarding mathematics ability
Pre-teaching questionnaire, questions one to five	Pre-teaching questionnaire, question six
End of unit mathematics test scores	
Post teaching questionnaire, questions one to six	Post teaching questionnaire, question seven
	Focus group discussions

Table 3.4: Categorisation of data for analysis

In order to support my analysis of the quantitative data generated, I created datasets for each aspect of data collected, and to do this I used the statistical software package SPSS (Statistical Package for the Social Science). This was to enable me to collate the data in a manageable form and to give me access to the tools I might need to support my statistical analysis (Muijs, 2011; Robson, 2011). As each question within the questionnaire had been designed to support specific research questions, this enabled the data to be analysed with these specific questions in mind. I was also aware that quantitative data analysis is more than just a presentation of the statistics themselves and that there would be a need to explain the findings and interpret their meaning (Newby, 2010; Creswell & Piano Clark, 2011).

In order to organise the qualitative data in a format that I would be able to analyse (Gibson, 2010; Creswell & Piano Clark, 2011), I used the process of transcription to transcribe the qualitative data from the questionnaires and the verbal data from the focus group discussions, which had been recorded using a digital voice recorder. The qualitative statements from audits and questionnaires were transcribed exactly into a word processing document, so none of the data was omitted. For the focus group discussions, a professional transcription service was used to initially transcribe discussions, allowing for a cross checking of transcription between the transcriber and myself as the researcher, hence enhancing the reliability of what the transcription. Having full transcripts of the qualitative data left me in a position to be able to carry out an analysis.

Newby (2010) suggests that qualitative data needs to be reorganised and reconstructed in order for it to be analysed and that one way of doing this is to use some form of coding system to support the process of identifying themes within the data, an approach consistent with others examining this area (Gibson, 2010; Creswell & Piano Clark, 2011; Baumfield, et al., 2013). To do this I constructed two forms of thematic coding to support my analyses, whereby I identified segments of data which were coded to a specific theme, enabling me to compare and contrast such themes within my analysis (Robson, 2011). Firstly, I used colour coding to identify consistent themes arising out of the statements and discussions of the participants, and secondly I used symbols for identifying positive, negative and neutral elements linked to these themes. My aim was that in using a consistent approach across all three aspects of the qualitative data, I would be able to identify any commonalities or discrepancies between them. One of my concerns in using this approach was that I would bring my own interpretation to such an analysis, and as such this could cause a threat to the reliability of the data. In order to minimise this, I used two additional processes.

Firstly I considered the role of computer assisted qualitative data analysis (CADQAS) to help me to identify any recurrent themes that had not been indentified elsewhere. I was aware that the use of such a package might support me in managing a large volume of data, but I was also aware that using such an approach might narrow my analysis and I may miss some of the subtleties that could occur through the provision of qualitative data (Silverman, 2005). I therefore decided to use the computer programme NVivo as a supplementary programme, rather than a standalone tool to support my analysis. Secondly, my codes were reviewed by two of my colleagues and also my supervisor to allow for inter-rater reliability and to support me in identifying any themes that I may have overlooked (Cohen, et al., 2000; Muijs, 2011).

A point to note here is that during the process of analysis of the audits, pre-teaching questionnaires and post-teaching questionnaires, it became apparent that there was a consistency in the themes that were identified. Hence, for the analysis of the focus group discussions, the concept of thematic coding was expanded to utilise the process of template coding analysis (King 2004). The development of this process will be discussed in detail in Chapter 7.

3.7 Ethics

The British Educational Research Association (BERA) provide ethical guidelines for researchers conducting educational research within Britain, and these guided the ethical considerations in carrying out this project (BERA, 2011). Alongside this, I also needed to ensure that I worked within the ethical requirements of my employer and the institute where I was studying, the University of Warwick. Consent was given from my Head of Department to carry out research with the students on the BA Applied Education Studies Course. Once this was given, in order to comply with the requirements of the University of Warwick (Hammond, 2010), an ethical approval form was completed and approval given by the Chair of the Ethics Committee (Appendix G).

BERA (2011) state that all participants in research should understand and agree to participation without duress, and that this must be of particular consideration where the researcher has a dual role of both teacher and researcher, a position that I found myself in. In order to conform to these guidelines, all participants were made aware of their rights of voluntary informed consent, both verbally at the start of the research and in writing (Appendix H) and that they had the right to withdraw from the research at any time. In particular, when discussion arose regarding the audit information, students were advised that their individual data could be removed from the sample should they not wish their data to be part of the research and that student data would be anonymised to ensure that individual students could not be identified. Questionnaires were completed anonymously, so it was not possible for me to identify any single individual from the responses.

In terms of participants' right to privacy, BERA (2011) identify that confidentiality and anonymity is seen as the norm when conducting research. As all participant data was anonymised in the audit and questionnaires were collected anonymously, participants could be assured that no one individual student would be able to be identified from the research. With regards to the focus group discussions, students who were part of these groups were known to each other, and hence complete anonymity could not be guaranteed; however, confidentiality in terms of what was discussed within the focus groups was agreed between me as the researcher and the students who participated at the start of each focus group discussion. Once the discussions had been transcribed, all responses were anonymised and no students were named within the study, hence providing anonymity within material produced as a result of the research.

Denscombe (2010) advises that all research should comply with the laws of the land, and as such, I aimed to comply with the 1998 Data Protection Act, which BERA (2011) states that participants in research 'are entitled to know how and why their personal data is being stored to what uses it is being put and to whom it may be made available' (p.7). In light of this, students were assured that all anonymised data would be kept in password protected electronic files that only myself and my supervisors would have access to. Any data that would be used to support them in their studies, such as audit data and mathematics tests results, was kept within University systems as part of their student records, and as such they had free access to personal individual data. They were also made aware that the findings of this data would be made available through the publication of my doctoral thesis.

I was also mindful of advice that carrying out my research would not be of detriment to the participants in the research (BERA, 2011), and that I should be aware of the consequences of my own actions (Oliver, 2003). As such, I was aware that I was researching a potentially emotive area of research, and of my responsibility to cease my research should there be any such detriment to the participants of the research. I was also aware of my responsibilities in my dual role as teacher and researcher and that my first responsibility was to my students and not my research (BERA, 2011).

3.8 Timetable for Research

Potter (2006) advises that the post-graduate researcher should devise a clear plan for organising and monitoring research, with the need to reviewing actions as the process develops. With this in mind, and the potentially overwhelming nature of organising a long term project, Table 3.5 outlines the overall thesis schedule. It is to be noted that due to unavoidable personal circumstances, the write up phase took longer than anticipated, but sufficient time had been planned for to allow for unexpected delays.

Overall Thesis Schedule		
1	Initial research proposal	January 2010
2.	Construction of pilot research methods	May 2010 to January 2011
3.	Pilot study	June 2010 to February 2011
4.	Review and adaptation of research design and methods	February to May 2011
5.	Audits	June 2011
6.	Pre-teaching questionnaires	November 2011
7.	Initial analysis of pre-teaching questionnaires	December 2011
8.	Post-teaching questionnaires	February 2012
9.	Focus group discussions	June 2012
10.	Initial analysis of questionnaires	June to August 2012
11.	Literature review write up	September 2012 to December 2012
12.	Methodology write up	January 2013 to March 2013
13	Presentation and analysis of individual elements of data collection	March 2013 to December 2013
14	Combined analysis of data	January 2014 to March 2014
15	Completion of write up	April 2014
16.	Final editing of thesis	May/June 2014
17	Submission of thesis	End of June 2014

Table 3.5: Research schedule

3.9 Conclusion

In this section I have outlined the approaches taken in planning and carrying out my research. This includes identifying the context for my research and the philosophical approach I have taken. In identifying that a mixed methods approach was appropriate for my research design, I have justified my research methods and considered the possible threats to the validity and reliability of my study, including the issue of my dual role as a practitioner-researcher. In identifying the timescales for my research, I aimed to establish a feasible time-frame in which to complete my study. Having now set the scene for my research design, I will now turn to the initial data collected from the sample to provide greater detail in regards to the context of my work.

Chapter 4: Presentation and Analysis of Existing Data

4.1 Introduction

In the previous section I identified that my first steps in the data analysis process would be to explore the existing data that was available, which comprised of the group statistics collected by the administration team in May 2011 and the audit data collected in June 2011. In order to do this, the objectives of this section are as follows:

- To review the background data to the research sample to include mode of attendance, age, gender, ethnicity and highest mathematics qualification
- To present and analyse the students' audit percentage scores and confidence levels.
- To present and analyse the students' qualitative comments
- To consider any potential links identified within the data collected
- To establish how the findings from the existing data impacted on the construction of the pre-teaching questionnaire.
- To consider the findings of the audit data in light of the first two research questions.

4.2 Presentation and Analysis of Background Data

The group statistics collected by the administration team included information regarding the students' age, gender and ethnicity and was analysed to provide background information concerning the research sample. All data was anonymised, so no personal student information was available, and this enabled me to build a picture of the nature of the day and evening cohorts, as well as the two cohorts combined. The total sample consisted of 75 students, 34 attending the daytime and 41 attending the evening delivery of the course.

Table 4.1 shows the age band spread at the start of the course, demonstrating a higher proportion of students within the lower age bands in the day group, with 20 out of 34 (58%) students below the age of 30 at the start of the course compared to 18 out of 41 (44%) students in the evening group. These findings are evidenced further when exploring the mean ages of the two groups, demonstrating a mean age of 28 (SD 9.7) in the day group compared to 32 (SD 9.5) in the evening group. In terms of gender spread, both groups had a high proportion of female students with 65 of the 75 (87%) of students being female (Table 4.2). With such a large proportion of female students this would make it difficult to make gender comparisons within this research and I am unlikely to contribute to discussions regarding gender differences as identified earlier (Hembree, 1990; Hopko, Mahadevan, Bare, & Hunt, 2003; Jones & Smart, 1995).

With regards to ethnicity, there was a close match in the ethnic composition of the two groups, with a total 58/75 (80%) students being of White British Heritage. Other cultures represented within the two groups included Bangladeshi, Indian, Pakistani, Black Caribbean and Mixed Heritage (Appendix J). As within the gender spread, with a large proportion of students coming from one ethnic background, it would be unlikely that I would contribute to discussions regarding ethnicity within this research.

Day and evening groups age band at the start of the course: Crosstabulation					
			Day or eve		Total
			Day	Evening	
Age at start	under 20	Count	10	1	11
		% within Day or eve	29.4%	2.4%	14.7%
	20 to 29	Count	10	17	27
		% within Day or eve	29.4%	41.5%	36.0%
	30 to 39	Count	7	13	20
		% within Day or eve	20.6%	31.7%	26.7%
	40 to 49	Count	7	9	16
		% within Day or eve	20.6%	22.0%	21.3%
	50 and over	Count	0	1	1
		% within Day or eve	0.0%	2.4%	1.3%
Total		Count	34	41	75
		% within Day or eve	100.0%	100.0%	100.0%

Table 4.1: Age band spread at the start of the course

Day and evening groups: Gender crosstabulation					
			Gender		Total
			Female	Male	
Day or eve	Day	Count	32	2	34
		% within Day or eve	94.1%	5.9%	100.0%
	Evening	Count	33	8	41
		% within Day or eve	80.5%	19.5%	100.0%
Total		Count	65	10	75
		% within Day or eve	86.7%	13.3%	100.0%

Table 4.2: Gender distribution

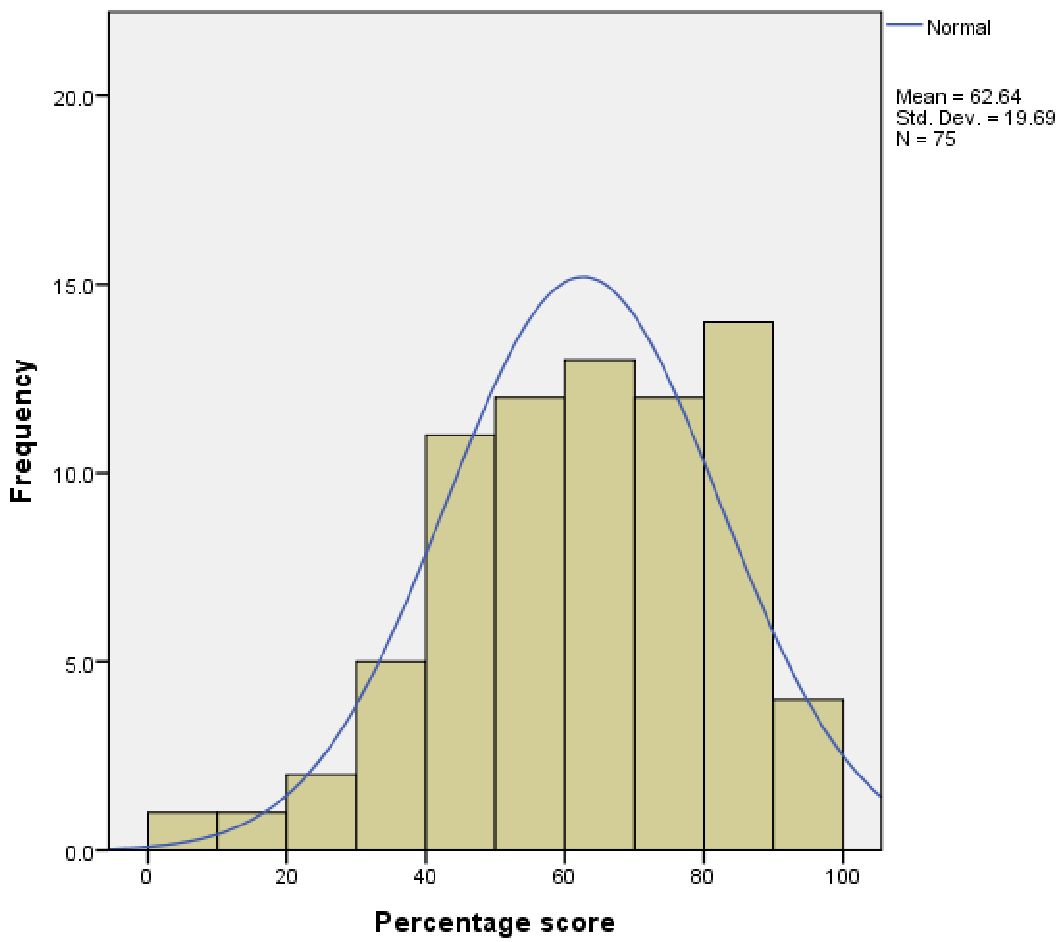
In order to consider the mathematical background of the students, I examined the mathematics qualifications that the students had on entry to the course (Table 4.3). My purpose for considering this, was that entry into teacher training requires that students have achieved either a Grade C, or equivalent, in GCSE mathematics (Department for Education, 2013) and may be a reason that students have chosen to pursue further study in this area (Ward-Penny, 2009). In terms of these qualifications, it is here that there are the biggest group differences, as 11 out of 34 (33%) students within the day group had not yet achieved a grade C GCSE or higher, compared to 20 out of 41 students (49%) within the evening group. This may be a factor to consider within further analysis of the data.

Day and evening groups highest mathematics qualification crosstabulation									
			Highest mathematics qualification						Total
			AS level or above	GCSE A* to C	GCSE D to G	Other mathematics qual	No mathematics qual	Not identified	
Day or eve	Day	Count	1	21	7	3	1	1	34
		% within Day or eve	2.9%	61.8%	20.6%	8.8%	2.9%	2.9%	100.0%
	Evening	Count	1	19	12	4	4	1	41
		% within Day or eve	2.4%	46.3%	29.3%	9.8%	9.8%	2.4%	100.0%
Total		Count	2	40	19	7	5	2	75
		% within Day or eve	2.7%	53.3%	25.3%	9.3%	6.7%	2.7%	100.0%

Table 4.3: Highest mathematics qualification

4.3 Presentation and analysis of audit percentage scores and confidence levels

All 75 students completed their initial audits, and percentage scores for the full sample are identified in Graph 4.1. Using the Shapiro Wilk test for normality, the p-value is greater than 0.05, demonstrating that these scores follow a normal distribution (p = 169, Table 4.4). These are consistent with the distributions of the individual groups (Appendix K).



Graph 4.1: Audit percentage scores for the day and evening groups combined

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Percentage score	.078	75	.200*	.976	75	.169
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Table 4.4: Tests of normality for the day and evening percentage scores combined

On examination of the mean and standard deviation of the two groups, there is a consistency between the higher levels of mathematics qualifications and the audit percentage scores, with the day group outperforming the evening group with a + 6% difference in their mean scores (Table 4.5). As the data follows a normal distribution, the t-test for independent samples has been used to demonstrate that there is no significant difference between the day and evening group percentage scores (t = 1.26, df = 73, p =0.213, Table 4.6). Hence, the overall mean percentage score of 62.64 (SD = 19.96) may be considered as representative of the combined groups (Graph 4.1).

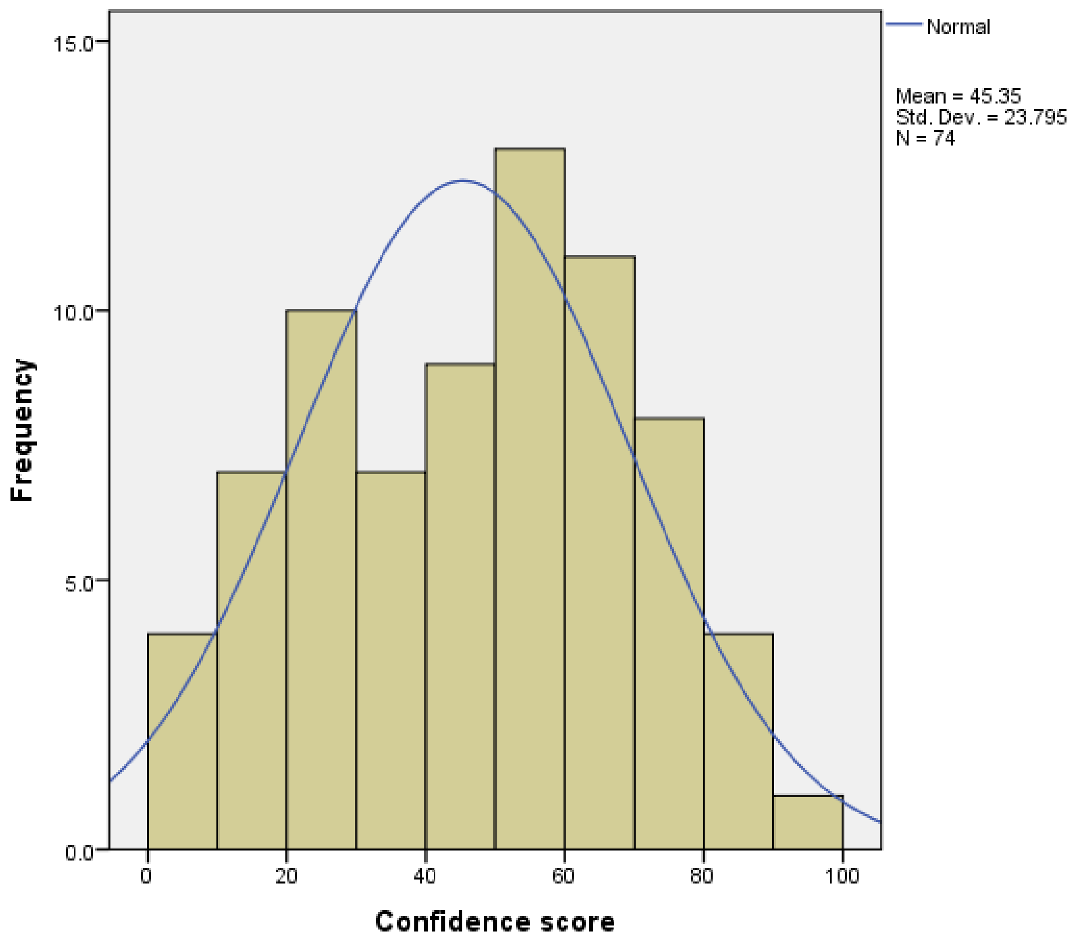
Group means for the audit percentage scores					
	Day or Eve	N	Mean	Std. Deviation	Std. Error Mean
Percentage score	Day group	34	65.76	18.223	3.125
	Evening group	41	60.05	20.691	3.231

Table 4.5: Mean audit percentage scores

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Percentage score	Equal variances assumed	.100	.753	1.256	73	.213	5.716	4.549	-3.351	14.783
	Equal variances not assumed			1.272	72.713	.208	5.716	4.495	-3.244	14.676

Table 4.6: Independent samples t-test for audit percentage scores

The distribution of the confidence scores for the combined groups is less clear, as although there is some evidence of a normal distribution, there is more variation throughout the range of distribution, and in particular a number of outliers at the lower confidence levels (Graph 4.2). Please note that one student chose not to rate their confidence level, hence the number of students considered here is 74. In using the Shapiro-Wilk test for normality, the p-value is greater than 0.05, demonstrating that the data follows a normal distribution (Table, 4.7, p = 0.054).



Graph 4.2: Audit confidence scores for the day and evening groups combined

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Confidence score	.094	74	.100	.968	74	.054
a. Lilliefors Significance Correction						

Table 4.7: Tests of normality for the day and evening confidence scores combined

In examining the mean confidence scores for each group (Table 4.9), there is a consistency within the data in that the day group have a higher mean confidence level than the evening group by + 6%, mirrored within the mean percentage scores discussed earlier. Similarly to the audit percentage scores, as the data follows a normal distribution, the t-test for independent samples was used to identify that there was no significance difference between the mean confidence scores of the day and evening groups (t = 1.07, df = 27, p (0.288), Table 4.10) and the combined mean confidence score of 45.35 (SD = 23.80) for the day and evening groups can be considered representative of the two groups (Graph 4.2).

One final consideration in relation to the data related to the confidence scores for both groups was that it was recognised that the Shapiro-Wilk test for normality had a p-level close to 0.05. Therefore a second test which considers that the data does not follow a normal distribution was carried out. The Mann-Whitney test for independence, which also demonstrates that there is no significant difference between the two groups and confirms that the mean scores of the combined groups can be considered representative (Table 4.8, U=584, p = 0.297).

Test Statistics[a]	
	Confidence score
Mann-Whitney U	584.000
Wilcoxon W	1404.000
Z	-1.043
Asymp. Sig. (2-tailed)	.297
a. Grouping Variable: Day or Eve	

Table 4.8: Mann-Whitney U-Test for Confidence Scores

Group means for the audit confidence scores					
	Day or Eve	N	Mean	Std. Deviation	Std. Error Mean
Confidence score	Day group	34	48.56	22.936	3.934
	Evening group	40	42.63	24.456	3.867

Table 4.9: Mean audit confidence scores

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Confidence score	Equal variances assumed	.475	.493	1.070	72	.288	5.934	5.545	-5.120	16.988
	Equal variances not assumed			1.076	71.276	.286	5.934	5.516	-5.064	16.931

Table 4.10: Independent samples t-test for audit confidence scores

Although there was some level of difference between the audit percentage scores and the perceived confidence levels, I have established that there was no significance between the mean scores for each of these variables for the day and the evening group. As a result, I have therefore focussed my further analysis of these two variables on the combined scores of both groups to establish if there was a correlation between percentage scores and perceived confidence levels. Using Pearson's r correlation coefficient, it is possible to identify that there is a strong correlation between percentage score and confidence score, positive correlation coefficient 0.620, $p < 0.01$ (Table 4.11).

Correlations			
		Percentage score	Confidence score
Percentage score	Pearson Correlation	1	.620**
	Sig. (2-tailed)		.000
	N	75	74
Confidence score	Pearson Correlation	.620**	1
	Sig. (2-tailed)	.000	
	N	74	74
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 4.11: Correlation between percentage and confidence scores

4.4 Presentation and analysis of audit comments

Having established a potential positive correlation between percentage scores and confidence levels, and that confidence levels were lower than percentage scores, I turned to the students' qualitative comments where they were given the opportunity to respond to the following:

'If there is anything else you would like me to know regarding your mathematical ability, please write it here. This may include hopes and fears or areas of mathematics you find particularly straightforward or challenging.'

A total of 55 comments were made, 26 from the day group and 29 from the evening group. As explained within the methodology, I constructed thematic coding systems to aid me in identifying common themes within the data which demonstrated how students were disposed towards learning mathematics. In my initial analysis, having transcribed the comments from every student, I used colour coding to identify whether or not the comments contained positive or negative wording, and used arrow symbols to identify whether or not a comment contained positive or negative comments (or both). It became clear that there was a third tier to each of these and those were 'aspirational' type comments, where students identified a desire to improve their mathematics and additional colours and symbols were added as appropriate. As a result of this, the comments were analysed in the following way:

Key

Pink: Negative vocabulary

Green: Positive vocabulary

Yellow: Aspirational vocabulary

↓ : Negative comment

↑: Positive comment

→: Aspirational comment

Student comment	**Direction of comment**
Algebra – not confident; fractions – rubbish; percentages – rubbish	↓
Some areas of maths I am strong in and others I struggle with and so I would like to balance out my level of maths to be good of most areas.	↓ ↑ →
I feel that I struggle with maths because I feel I may be dyslexic or dyscalculic and am going to the process of being officially assessed. That aside I am more confident about maths than I have been although I know it is one of my weaker areas.	↓ ↑

Table 4.12: Example of coding used in the analysis of student comments

It would not be feasible to include all of the individually analysed comments here, so a summary of the total number of positive, negative and aspirational comments is shared in Table 4.13:

	Number of negative comments	**Number of positive comments**	**Number of aspirational comments**
Day group	22	8	10
Evening group	21	9	9
Combined totals	**43**	**17**	**19**

Table 4.13: Initial analysis of audit comments

The results demonstrate that more than half of both the day and evening group students had a negative perception of mathematics, exemplified in comments such as ‘Maths is one of my weaker subjects and my confidence in this is very low’ and ‘I find mathematics difficult and generally struggle with it’. There were two students who identified mathematics within only a positive light by expressing an enjoyment in the subject.

Table 4.14 shows the spread of combined views where students’ comments expressed a combination of two or more perceptions regarding their learning of mathematics. Twenty three of the students commented in this way, demonstrated within the comment from this student who expressed positivity, negativity and an aspiration to improve: ‘I was very good at maths in school, but since then through lack of practice and other circumstances, I haven’t been able to improve. Hopefully with hard work I can be more confident with maths’. One student identified themselves as rubbish, frightened and hating mathematics and presented a challenging viewpoint, saying ‘If you can teach me maths, then you deserve an Oscar!’

	Negative and positive comments	**Negative and aspirational comments**	**Positive and aspirational comments**	**Positive, negative and aspirational comments**
Day group	4	5	1	3
Evening group	3	4	1	2
Combined totals	**7**	**9**	**2**	**5**

Table 4.14: Combined perceptions of audit comments

An analysis of the language used in discussing mathematics revealed a consistency within the words used to describe the students' perceptions of learning mathematics. In light of this, the top five positive and negative were identified and used to create the first question of the pre-teaching questionnaire (Appendix C):

Positive	**Negative**
Confident	Unconfident
Enjoy	Struggle
Strong	Weak
Interest	Fear
Easy	Difficult

Table 4.15: Descriptive vocabulary identified from the audits

Having explored the students' attitudes towards learning mathematics, and the vocabulary associated with these attitudes, it became apparent that there were additional themes arising from the analysis and these were related to specific experiences of the individuals in affecting their ability to carry out mathematics. Three themes were discussed within the comments, those of personal perceptions, subject knowledge and the role of others:

Personal Perceptions

Of the twenty five students who commented on their own perceptions regarding learning mathematics, sixteen of these expressed the view that mathematics was a difficult subject and not something that they were able to do. Comments such as, 'I am not at all confident in maths. I have almost put a barrier up' and 'Out of all of the subjects I studied at school maths was the subject I was scared of and still am' demonstrate these perceptions. Other comments relating to personal perceptions included five students who saw mathematics as enjoyable and something that they were able to do, and four who identified the need for personal practice to support their learning.

Subject Knowledge

Twenty one students made reference to specific aspects of subject knowledge that they were either confident about or had found particularly challenging within the audit. Concerns were consistently raised regarding the understanding of algebra, fractions and percentages. One student expressed concern that she would not be able to complete mathematics questions accurately without a calculator.

Role of Others

Nine students identified the effect that others had on their perceptions of learning mathematics, including suggestions that their understanding was affected by the teacher, in comments such as ‘I found maths difficult at school and didn’t get much guidance from the teacher’. Others referred to being made to feel a failure by either parents or peers, and three students identified a need for additional support from someone, but did not identify who that ‘someone’ might be.

4.5 Summary

In examining the initial audit data, I aimed to explore the first two research questions in order to identify the perceptions students had before embarking on their first mathematics education course (RQ1) and the past factors that might have affected how they felt towards learning mathematics (RQ2). Comparing the means of the percentage and confidence scores demonstrates that students rated themselves lower in confidence than in attainment (Tables 4.4 and 4.7). In analysing the students’ comments, 43 of the 55 participants who chose to respond included negative perceptions and the proportions of negative to positive comments revealed a ratio of 43 to 17, close to a ratio of 2 to 1. Their comments are consistent with the findings of those who have identified a lack of confidence and negative emotions related to learning mathematics (Boaler, 2009; Evans, 2002; Tobias, 1993).

Additional analysis supports the identification of factors that may have affected the students' perceptions of learning mathematics, these being their level of subject knowledge, their personal perceptions and the influences of others. Bibby (2002) and Brady and Bowd (2005) have established links between adults' past experiences and feelings related to mathematics, and this was reflected in the opinions of these students, particularly in relation to the 25 students who discussed the effect of their personal perceptions on their ability to learn mathematics.

As the audit tool was originally designed to gain background information for the purposes of teaching the students their first mathematics education unit, the conclusions drawn in relation to the research questions may be somewhat limited. The pre-teaching questionnaire was specifically designed to explore these questions in more detail and will be discussed in the next chapter.

Chapter 5: Presentation and Analysis of Pre-Teaching Questionnaire

5.1 Introduction

In the previous section I examined the background data of the students in order to establish the age range, gender, ethnicity and highest mathematics qualifications of the sample group. I also explored the audit data to examine the students' percentage scores and perceived confidence levels in mathematics. The students' comments were analysed to establish if there were any factors that stood out as having the potential to affect their perceptions towards learning mathematics. This data allowed an initial examination of the first two research questions. A pre-teaching questionnaire was then designed to examine these questions in greater depth (Chapter 3.2). The questionnaires were distributed within a colleague's teaching session in November 2011. Of the total sample of 75 students, 68 completed the questionnaires, a response rate of 27/34 from the day group and 41/41 from the evening group. The purpose of this section is to present and analyse the findings of this data, with the specific objectives as follows:

- To present and analyse the quantitative data exploring positive and negative perceptions of mathematics, perceived understanding and perceived confidence in learning mathematics.
- To present and analyse quantitative data on the types of learning environments student had been exposed to in the past and the factors they felt might have affected their learning of mathematics.
- To present and analyse the qualitative comments on experiences the students identified as having affected how they felt about mathematics.

- To consider the findings of the pre-teaching questionnaire in light of the first two research questions.
- To triangulate the findings from the audit with the pre-teaching questionnaire.

5.2 Presentation and analysis of quantitative data

Question 1 asked the participants to identify any of the five positive and five negative words listed from the analysis of the audit identified in 4.15. As many or as few words could be circled as the students wished and all students chose to answer this question. Across the day and evening cohorts, a total of 247 words were identified and the spread was as follows:

Positive words					Negative words			
Word	**Day**	**Eve**	**Total**		**Word**	**Day**	**Eve**	**Total**
Strong	5	4	9		Weak	12	20	32
Interest	10	17	27		Fear	8	20	28
Easy	4	4	8		Unconfident	14	23	37
Confident	9	8	17		Struggle	14	19	33
Enjoy	12	14	26		Difficult	10	20	30
Totals	**40**	**47**	**87**		**Totals**	**58**	**102**	**160**

Table 5.1: Identification of positive and negative vocabulary

Further analysis of the spread of the words identified demonstrated a higher proportion of negative to positive words, and overall this was in a ratio of 160 to 87, close to 2:1 for the combined groups (Table 5.1). This is consistent with the negative views of mathematics identified within the audit comments, although perhaps represents a fuller picture of the sample group as all students chose to respond to this question. In terms of the individual cohorts, the evening group maintained a more negative view of mathematics in comparison to the day group, which may be reflective of the lower number of students having achieved GCSE Grade C or higher than in the day group (Table 4.3). Despite this, both groups maintained a more negative disposition towards mathematics than positive (Table 5.2):

	Day	**Evening**	**Total**
Total number of comments	98	149	247
Positive comments	40 (41%)	47 (32%)	87 (35%)
Negative comments	58 (59%)	102 (68%)	160 (65%)

Table 5.2: Breakdown of comments by group

All students answered Question 2 where they were asked to rate their perceptions of understanding mathematics on a Likert type scale from 1 to 5, with 1 being ‘I do not understand mathematics’ to 5 being ‘I have a very good level of understanding in mathematics’. The range of perception scores is shown in Table 5.3:

Perceived level of understanding for day and evening groups: Crosstabulation					
			Day or eve		Total
			Day	Evening	
Understanding	Low level of understanding	Count	4	11	15
		% within Day or eve	14.8%	26.8%	22.1%
	Reasonable level of understanding	Count	14	22	36
		% within Day or eve	51.9%	53.7%	52.9%
	Good level of understanding	Count	6	7	13
		% within Day or eve	22.2%	17.1%	19.1%
	Very good level of understanding	Count	3	1	4
		% within Day or eve	11.1%	2.4%	5.9%
Total		Count	27	41	68
		% within Day or eve	100.0%	100.0%	100.0%

Table 5.3: Cross-tabulation of perceived levels of understanding

There were no students with ‘no understanding of mathematics’ and just over half of the cohort of students (36 students, 53%) took the middle ground in identifying themselves as having a reasonable level of understanding. The evening group had a higher proportion of students than the day group with a low level of understanding in learning mathematics, with 11 out of 41 students compared to 4 out of 27 (eight percentage points difference) choosing this option. This is consistent with lower levels of mathematics qualifications (Table 4.3) and lower percentage and confidence scores within the audit (Tables 4.5 and 4.9) identified within the evening group statistics.

Question 3 asked the students to rate their perceptions of confidence in learning mathematics, on a Likert type scale from 1 to 5, with 1 being ‘I do not feel confident about learning mathematics’ to 5 being ‘I feel very confident about learning mathematics’. 66/68 students answered this question. The spread of results can be seen below (Table 5.4).

Perceived level of confidence for day and evening groups: Crosstabulation					
			Day or eve		Total
			Day	Evening	
Confidence	Do not feel confident	Count	2	2	4
		% within Day or eve	7.4%	5.1%	6.1%
	Low level of confidence	Count	2	12	14
		% within Day or eve	7.4%	30.8%	21.2%
	Reasonable level of confidence	Count	11	13	24
		% within Day or eve	40.7%	33.3%	36.4%
	Confident	Count	8	11	19
		% within Day or eve	29.6%	28.2%	28.8%
	Very confident	Count	4	1	5
		% within Day or eve	14.8%	2.6%	7.6%
Total		Count	27	39	66
		% within Day or eve	100.0%	100.0%	100.0%

Table 5.4: Cross-tabulation of perceived levels of confidence in learning mathematics

As within the perceived levels of understanding, the evening group maintained a consistency in identifying lower levels of confidence, with 14 out of 39 (36%) students categorising themselves as having a low level or no confidence in learning mathematics, compared to 4 out of 27 students in the day group (14%). When comparing the overall levels of perceived confidence, 25 of the 66 students (37%) identified themselves as confident or very confident in learning mathematics, 9 percentage points higher than the overall perceived levels of good to very good understanding (17 students, 25%, Table 5.3). Using Spearman's rho correlation coefficient, a strong positive correlation between perceptions of understanding and confidence was identified for the individual day and evening groups (Appendix L). This correlation is maintained for the combined groups, where a there is a strong positive correlation coefficient of 0.707, $p < 0.01$ (Table 5.5):

Day and evening combined: Correlation of perceived understanding and confidence				
			Understanding	Confidence
Spearman's rho	Understanding	Correlation Coefficient	1.000	.707**
		Sig. (2-tailed)	.	.000
		N	68	66
	Confidence	Correlation Coefficient	.707**	1.000
		Sig. (2-tailed)	.000	.
		N	66	66
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 5.5: Correlation between perceived understanding and perceived confidence in learning mathematics

Question 4 explored the type of learning environments the students had been used to in the past, and the tables show the combined responses for the day and evening groups (Table 5.6). The raw data from which these were drawn can be found in Appendix M.

	Number of student responses			
Environment: Combined groups	**Not identified**	**Yes**	**No**	**Sometimes**
Allowed to ask questions	1 (2%)	39 (57%)	6 (9%)	22 (32%)
Encouraged to discuss answers	2 (3%)	20 (29%)	20 (29%)	26 (38%)
Allowed to work with a partner or in groups	3 (4%)	24 (35%)	23 (34%)	18 (27%)
Worked in silence	1 (2%)	41 (60%)	2 (3%)	24 (35%)
Encouraged to keep trying until understood	2 (3%)	31 (46%)	14 (21%)	21 (31%)
Worked completely alone	4 (6%)	27 (40%)	7 (10%)	30 (44%)

Table 5.6: Percentage of responses for environmental experiences

It is difficult to identify any significant conclusions at this point, other than to draw attention to the fact that 'working in silence' was identified as an environment that all but two students (3%)f had been exposed to. This may provide information to be considered when triangulating the data at a later point.

The students were also given the opportunity to add any other environments here, and two comments referred to materials they had used, including text books and online materials. Two students identified a lack of confidence in asking questions and in not wanting to ask questions or feeling embarrassed at asking for topics to be recapped. Three additional comments related to feeling de-skilled, the teacher being confusing and to mathematics being stressful.

Question 5 asked students to identify positive and negative influences from a list identified from the literature in Chapter 2. Participants also had the opportunity to identify any other factors they felt influenced them. Due to the fact that the data for the day and evening groups produced very similar results (Appendix N), the data for the combined groups is presented for consideration here (Table 5.7). A number of students identified factors as having both a positive and negative influence, and these are identified in the 'both' column.

Attendance at school					
	Not identified	Positive	Negative	Both	Total
Count	10	49	9	0	68
Percentage	14.7	72.1	13.2	0.0	100.0
Personal Behaviour at school					
	Not identified	Positive	Negative	Both	Total
Count	12	45	10	1	68
Percentage	17.6	66.2	14.7	1.5	100.0
Effect of the teacher					
	Not identified	Positive	Negative	Both	Total
Count	1	30	32	5	68
Percentage	1.5	44.1	47.1	7.4	100.0
Effect of other pupils					
	Not identified	Positive	Negative	Both	Total
Count	5	25	36	2	68
Percentage	7.4	36.8	52.9	2.9	100.0
Personal issues outside school					
	Not identified	Positive	Negative	Both	Total
Count	18	22	28	0	68
Percentage	26.5	32.4	41.2	0.0	100.0
Tests and exams					
	Not identified	Positive	Negative	Both	Total
Count	5	19	42	2	68
Percentage	7.4	27.9	61.8	2.9	100.0

Table 5.7: Positive and negative influences on learning mathematics

The effect of the teacher was identified by all but one student as having an influence, and had the highest response rate of all options given, being identified by all but one student (98% of the sample group). The breakdown of these responses identifies that the teacher was the third rated positive influence and the third rated negative influence, with five students identifying the teacher as both a positive and a negative influence. The other two factors with high response rates were tests and exams and the effect of other pupils, both being identified as an influencing factor by 63/68 (93%) of pupils.

Attendance and personal behaviour at school were rated as the top two positive influences, with over two thirds of the students identifying these as a factor. Similarly tests and exams and the effect of other pupils were rated as the top two negative influences, with over half of the students identifying these.

Of the five individual comments added to this question, two were related to both the positive and negative influences of the teacher, one related to the usefulness of a previous covered course, one to the ease of the audit assessment at the start of the degree and one on the use of encouragement at home.

5.3 Presentation and analysis of qualitative data

Having explored the quantitative elements of the pre-teaching questionnaire, I turned to the students' qualitative comments where they were asked to consider the following:

'Think about your perceptions of learning mathematics. Identify an experience that you think may have affected how you feel about the subject today. Please give as full a description of this experience and how you think it has affected your current feelings about learning mathematics'.

65 of the 68 participants responded, with 27 comments from the day group and 38 from the evening group. As for the audit data comments in the previous chapter, I constructed a thematic coding system to identify the most common themes identified by the students and whether they displayed a positive or negative disposition towards learning mathematics. In order to identify the themes I first familiarised myself with the data in order to search for meanings and patterns (Robson, 2011) and this allowed me to identify any initial patterns within the data. I was mindful of the influences affecting how people feel about learning mathematics identified within the literature review, which also supported my initial explorations; however, I was also aware that I did not want to limit my analysis to just the themes identified from reviewing literature. Therefore, to further support and develop my analysis, I used computer assisted qualitative data analysis software (CAQDAS), which enabled me to manage the quantity of data generated and to support the process of complex data searches (Newby, 2010).

Whilst familiarising myself with the data, I began to identify common themes within some of the comments and used colour coding to identify these themes. Consistent with the analysis of the audit comments, I also used arrow symbols to identify whether these comments were positive or negative. Here is an example of an analysed comment:

Grey: References to personal motivation

Green: References to the teacher

Blue: Reference to behaviour of self or others

↓: Negative comment

↑: Positive comment

Student comment	
I never particularly enjoyed maths lessons at school and it wasn't something I was amazing at but I worked hard. However in my GCSE year I had a poor teacher and a disruptive class. Very little learning happened. This meant that although I revised alone I only achieved a D at GCSE. I had to get a C. At sixth form I attended extra maths classes every week for a year, but the teacher wouldn't go over just the bit that we struggled with wasting learning time and talked to us as though we were stupid as we were having to retake. I then got two more D's in my re-takes so in the end I revised, taught myself what I needed and took the exam for the fourth time and finally got a C.	↓↓↑↓

Table 5.8: Example of coding used in the initial analysis of student comments (pre-teaching)

It would not be feasible to include all of the individually analysed comments here, but further examples can be found in Appendix P, along with the coding used; however, a summary of the full analysis and themes identified is presented in Table 5.9 and then explored in further detail. Please note that students often identified more than one theme within their individual comments.

	Day		Evening		Combined			
	Positive	**Negative**	**Positive**	**Negative**	**Positive**	**Negative**	**Total number of comments**	**Percentage of students commenting**
Attendance	0	1	0	1	0	2	2	3
Behaviour	0	4	1	2	1	6	7	11
Effect of the teacher	5	8	9	20	14	28	42	65
Personal influences outside school	0	2	0	4	0	6	6	9
Tests and exams	0	1	2	2	2	3	5	8
Public nature of doing mathematics	0	1	0	4	0	5	5	8
Personal perceptions	10	11	12	5	22	16	38	58
Setting arrangements	2	5	0	12	2	17	19	29
Current role	2	0	3	0	5	0	5	8
Specific aspects of mathematics	2	3	1	1	3	4	7	11
Support	0	3	1	1	1	4	5	8
Total number of comments	21	39	29	52	50	91	141	

Table 5.9: Summary of coded responses to narrative comments

In examining the types of influences identified for the combined groups, the ratio of negative to positive comments is 91 to 50 close to a ratio of 2:1 and maintains a consistency with the ratio of negative to positive perceptions identified in Tables 5.1 and 5.2. Over half of the students identified the effect of the teacher (42/65, 65%) and personal perceptions (38/65, 58%) as the top two factors which had influenced how they felt about mathematics, with setting arrangements ranked third by 19 students (29%). This ranking for the combined groups is consistent with that of the evening group; however, although the day group still ranked the effect of the teacher and personal perceptions as the top two factors, the students within this group ranked personal perceptions above the effect of the teacher. A range of additional factors was identified, but all of these accounted for responses from 7 students (11%) or less. Although these additional factors are acknowledged within the initial analysis of the data (Table 5.9), my intention is to focus on analysing the top three influences in more detail and to return to the other factors at a later stage should their identification become more pertinent within the later stages of the data analysis.

5.3.1 Theme 1: The effect of the teacher

65 of the 141 comments were related to the effect of the teacher, and this was the highest rated influence on learning mathematics, consistent with the findings from question 5 (Table 5.7) and of those who see the teacher as the overriding influence on how people feel about learning mathematics (Crook & Briggs, 1991; Bibby, 1999, 2002; Brady & Bowd, 2005); however, my intention had not been to limit the respondents' choices (Muijs, 2011) and therefore analysis of the qualitative data enabled me to explore this theme in more depth. This revealed that the comments

were split into two categories, those concerned with attributes relating to the teacher, and those relating to the nature of teaching.

In terms of characteristics, the nine of the positive comments were related to the supportive nature of the teacher who was seen as having been encouraging, enthusiastic, helpful, understanding and nurturing. This was demonstrated in comments such as ‘I feel the change in my attitude was due to an understanding teacher who supported the class well’ and ‘good teacher support throughout the years.’ In terms of negative influences, comments related to support were also at the top of the students’ identified influences (eight responses), stating that unsupportive teachers did not encourage or push them to perform well. For example, ‘I felt uneasy about the subject and was never encouraged to carry on’ and, ‘Didn’t get much support from the teacher even when it was highlighted that I had a lack of understanding’. The remainder of comments relating to the teacher were all negative, and students expressed feelings of humiliation and being scared by teachers who presented themselves as bullying or intimidating (six responses). Additional factors identified by other students included being taught by foreign teachers and not being able to understand them (four responses), and a lack of subject knowledge or appropriate qualifications (two responses).

In terms of teaching, the main factors affecting how the students’ felt about learning mathematics were linked to the quality of explanation and the pace of lessons (eleven responses). In these instances, positive comments related to the use of different methods to support explanation and having a ‘quiet structured classroom’; the negative comments, from eight students, related to a lack of explanation and to the teacher moving on too fast, for example, ‘When I was taught mathematics it was very much – ‘this is the way you do it’ type of approach. Not really given a thorough understanding of why and how the method worked.’

5.3.2 Theme 2: Personal perceptions

Although personal perceptions was not one of the areas provided for choice within question 5, it was nevertheless identified as the second rated factor overall in affecting how the students felt about learning mathematics and the top factor for the day group students. This is similar to the views of others exploring this area, who suggest that how a person feels about learning mathematics can affect their ability to understand it (Buxton, 1981; Tobias, 1993; Bekdemir, 2010). Of those who identified personal perceptions as a factor, positive comments focussed on the enjoyment of mathematics as a subject of interest (eleven responses) and four of these students also expressed a willingness to work hard in learning the subject. One participant suggested that 'I have always liked mathematics. I get numbers at a glance ... even as an adult I still love and enjoy mathematics. I still learn and strengthen my mathematical skills every day'. Others, who identified personal perceptions as a negative view, suggested that mathematics was a difficult subject to understand and not something within their capacity to learn (sixteen responses). For example, comments such as 'I find maths a struggle because it has never been easy or simple for me to understand it' and 'In GCSE I struggled because I was very negative about the subject and truly believed that I couldn't do it' suggests that some students may have a belief similar to that of the fixed mindset identified by Dweck (2007), whereby intelligence is fixed and nothing can be done to change it.

5.3.3 Theme 3: Setting arrangements

Consistent with those who have identified setting arrangements as a potential factor in causing mathematics anxiety (Tobias, 1993; Ward-Penny, 2009; Welder & Champion, 2011), seventeen of the nineteen students who chose to comment on this demonstrated a negative perspective regarding setting. Students felt that this issue was due to the fact that the work was too hard in the set they were placed in (eleven responses), reflected in comments such as ‘I was put in the top set. I was out of my depth’ and ‘The teacher moved me to a higher set. I felt as though I was suddenly moved off too quickly and suddenly’. Others suggested that setting arrangements limited their ability to achieve more highly (four responses). Regarding the two students who identified a positive disposition towards setting arrangements, both commented on the fact that the work was within their capability and that they were able to achieve the expectations within that set.

5.4 Summary

The purpose of the pre-teaching questionnaire was to explore the first two research questions and to triangulate the findings with the data from the existing dataset discussed in the previous chapter. In order to do this, I will return to these two questions and summarise the key findings so far.

RQ1: What perceptions do students have regarding learning mathematics before embarking on their first mathematics education course?

Findings from both the audit data and the pre-teaching questionnaire showed that a higher proportion of students demonstrated negative rather than positive perceptions of learning mathematics. Within the analysis of audit comments, a ratio of approximately 2 to 1 students identified a negative to positive disposition towards learning mathematics (Table 4.13) which was similarly reflected within the pre-teaching questionnaire through the identification of vocabulary choices in question 1 (Table 5.2) and the analysis of qualitative comments in question 6 (Table 5.9).

Findings from the initial audit established a strong positive correlation between audit percentage scores and perceived confidence scores (Pearson's r correlation coefficient, positive correlation coefficient 0.620, $p < 0.01$, Table 4.11). In exploring this further within the pre-teaching questionnaire, a consistent link between understanding and confidence was identified, by establishing a strong positive correlation between perceived understanding and perceived confidence (Spearman's rho correlation coefficient, positive correlation coefficient of 0.707 $p < 0.01$, Table 5.5). In terms of confidence, there was a difference of eighteen percentage points between the audit scores and perceived confidence levels, with students identifying themselves as less confident than their percentage scores might demonstrate (Tables 4.4 and 4.7), and just over one quarter of students (18/66) identifying themselves as having a low level of confidence or no confidence within the pre-teaching questionnaire (Table 5.4). It is to be noted here that although all students identified that they had some level of understanding in mathematics, but there were four students who perceived themselves as having no confidence in the subject (Tables 5.3 and 5.4).

RQ2: What past factors have affected students' perceptions of learning mathematics?

Although findings from the audit data demontrated that the students had a more negative rather than positive disposition towards learning mathematics, the qualitative comments mainly gave the students' views in regards to how they felt about mathematics rather than the factors that had affected them in the past. However, within the audit, students commented on their difficulites in learning mathematics and being made to feeling humiliated or scared by the teacher. These themes are expanded upon within the pre-teaching questionnaire comments, with the effect of the teacher and personal perceptions being identified as the top two influences in how students felt about learning mathematics (Table 5.9). Other factors identified as affecting how students felt about learning mathematics included tests and exams, and personal behaviour at school (Table 5.7) and setting arrangements (Table 5.9).

5.5 Next steps

The audit and pre-teaching questionnaire provided data in support of the first two research questions, demonstrating that a higher proportion of these students had a negative rather than postive view of learning mathematics and that key themes could be identified as having the potential to affect this view. In terms of those exploring the issue of low confidence in mathematics, strong negative emotions towards learning mathematics are identified as symptoms of mathematics anxiety (Crook & Briggs, 1991; Bibby, 2002; Brady & Bowd, 2005). In comparing the postive correlations between low performance and low confidence from the audit data with the meta-analysis of Hembree (1990), it may be possible to establish that where there is low performance in mathematics, there may also be high anxiety. There is also the suggestion that where anxiety and low confidence exists, the teacher is the main influence (Hodgen & Askew, 2006; Ashcraft & Krause, 2007; Ward-Penny, 2009; Bekdemir, 2010), consistent with the key influencing factor identified by the students. Taking these factors into consideration, this therefore suggests that within this sample group of students, amongst those displaying a negative disposition towards learning mathematics, there may be a number of students demonstrating symptoms of low confidence and anxiety in learning mathematics.

The purpose of the next stage of the research is to explore whether or not there are any differences between the students dispositions towards learning mathematics before and after their first mathematics education unit as undergraduates, and whether or not there might be any percieved factors that might support the students in learning mathematics.

Chapter 6: Presentation and Analysis of Post-Teaching Questionnaire

6.1 Introduction

In the previous section, I presented and analysed the data collected from the pre-teaching questionnaire and triangulated the data with the findings from the audit. The purpose of this was to identify the perceptions that students had regarding learning mathematics and the factors that they felt had affected these perceptions. In analysing the data, I was able to establish that a greater proportion of students identified themselves as having a negative rather than positive view of learning mathematics (close to two to one) and that there was the possibility that within the more negative group, there were students who had low confidence in learning mathematics as well as those who displayed signs of being anxious about mathematics.

Following completion of the pre-teaching questionnaire, the students returned after the Christmas break to study their first mathematics education unit on the BA Applied Education studies course, and this took place over a six week period in January/February 2012. At the end of the unit, post-teaching questionnaires were distributed to the students. One student from the day group left the course during this unit, and hence this left a sample of 74 students. Of this sample, 64 chose to complete the questionnaire, a response rate of 27/33 from the day group and 37/41 from the evening group. The purpose of this section is to present and analyse the findings of this data, with the specific objectives as follows:

- To present and analyse the quantitative data exploring the positive and negative perceptions of mathematics, perceived understanding and perceived confidence in learning mathematics.
- To present and analyse the quantitative data exploring changes in perceptions regarding levels of understanding and confidence in learning mathematics.
- To present and analyse the quantitative and qualitative data on factors that may have affected how the students feel about learning mathematics.
- To compare and contrast the findings of the pre and post teaching questionnaires
- To consider the findings of the post-teaching questionnaire in light of research questions three, four and five.

6.2 Presentation and analysis of quantitative data

Questions 1 to 3 were repeated from the pre-teaching questionnaire to allow for a direct comparison regarding overall perceptions regarding learning mathematics. Students were given the same choice of words in Question 1, and were asked to identify as many or as few words that they associated with learning mathematics. A total of 314 words were identified across the two cohorts of students, and these were distributed as follows:

Positive Words					Negative Words			
Word	**Day**	**Evening**	**Total**		**Word**	**Day**	**Evening**	**Total**
Strong	9	15	24		Weak	4	12	16
Interest	20	47	67		Fear	2	10	12
Easy	7	13	20		Unconfident	7	17	24
Confident	16	30	46		Struggle	6	21	27
Enjoy	16	38	54		Difficult	8	16	24
Totals	**68**	**143**	**211**		**Totals**	**27**	**76**	**103**

Table 6.1: Identification of positive and negative vocabulary, post-teaching questionnaire

Analysis of the spread of words demonstrates that a higher proportion of positive words were chosen. The ratio of negative to positive words identified was 103 to 211, close to a ratio of 1 to 2 for the combined groups. In comparison to the pre-teaching questionnaire, this demonstrates a reversal of the proportions identified, which was close to 2 to 1 (Table 5.1).

In comparing the day and evening responses, the raw scores of both groups show an increase in the identification of positive and a decrease in negative vocabulary. To allow for comparison with the pre-teaching data, this has been translated to percentage points in Table 6.2.This shows an increase of 31 and 33 percentage points in the identification of positive vocabulary for the day and evening groups respectively, when compared to the data in Table 5.2, and the same percentage point decreases for negative vocabulary.

	Day	Evening	Total
Total number of comments	95	219	314
Positive comments	68 (72%)	143 (65%)	211 (67%)
Negative comments	27 (28%)	76 (35%)	103 (33%)

Table 6.2: Breakdown of comments by group

As for the pre-teaching questionnaire, question 2 asked the students to rate their perceived levels of understanding of mathematics on a Likert type scale. All 64 students answered this question (Table 6.3).

Perceived level of Understanding: Crosstabulation					
			Day or eve		Total
			Day	Evening	
Understanding	Low level of understanding	Count	1	2	3
		% within Day or eve	3.7%	5.4%	4.7%
	Reasonable level of understanding	Count	8	20	28
		% within Day or eve	29.6%	54.1%	43.8%
	Good level of understanding	Count	13	13	26
		% within Day or eve	48.1%	35.1%	40.6%
	Very good level of understanding	Count	5	2	7
		% within Day or eve	18.5%	5.4%	10.9%
Total		Count	27	37	64
		% within Day or eve	100.0%	100.0%	100.0%

Table 6.3: Cross-tabulation of perceived levels of understanding, post-teaching questionnaire

There were no students in either group who identified themselves as not understanding mathematics at all. A higher proportion of students within the day group compared to the evening group identified themselves as having a ‘good’ or ‘very good’ level of understanding, a difference of 27 percentage points, potentially reflecting the difference in the higher levels of mathematics qualifications within the day group (Table 4.3).

In comparing the results of this question to those from the pre-teaching questionnaire (Table 5.3), the number of students identifying themselves with a low level of understanding has dropped from 15 students to 3, a difference of 17 percentage points. In terms of the differences between the two cohorts, the gap has closed in this category, with a difference of less than 1% between the evening and day cohorts, compared to 12% identified in November 2012 (Table 5.3). With regard to overall perceptions of understanding when comparing the pre and post teaching questionnaires, the greatest differences can be found within those students who identified themselves as having a ‘good’ or ‘very good’ level of understanding of mathematics within the post teaching questionnaire, where the proportion of students more than doubled. 17/68 students (25%) identified themselves within these categories in the pre-teaching questionnaire (Table 5.3) compared to 33/64 (52%) students in the post teaching questionnaire (Table 6.3), an increase of 27 percentage points.

Consistent with the pre-teaching questionnaire, Question 3 asked to students to rate their perceived levels of confidence in learning mathematics. 63/64 students responded to this question and the results of this question are shown in Table 6.4.

Perceived level of confidence: Crosstabulation					
			Day or eve		Total
			Day	Evening	
Confidence	Low level of confidence	Count	3	4	7
		% within Day or eve	11.5%	10.8%	11.1%
	Reasonable level of confidence	Count	7	12	19
		% within Day or eve	26.9%	32.4%	30.2%
	Confident	Count	12	18	30
		% within Day or eve	46.2%	48.6%	47.6%
	Very confident	Count	4	3	7
		% within Day or eve	15.4%	8.1%	11.1%
Total		Count	26	37	63
		% within Day or eve	100.0%	100.0%	100.0%

Table 6.4: Cross-tabulation of perceived levels of confidence, post-teaching questionnaire

There were no students who identified themselves as having ‘no confidence’ in learning mathematics, and in comparing the combined percentages for ‘low’ levels of confidence between the two groups the gap between the two groups had closed from 24 percentage points (10 students, Table 5.4) to 5 percentage points (5 students, Table 6.4). Further to this, the number of students who identified themselves as confident or very confident, increased by 23 percentage points from 24/66 (36%) to 37/63 (59%).

There is a consistency within the changes in perceived perceptions within the understanding and confidence categories, with the lower categories decreasing and the higher categories increasing. This suggests that the students perceived that they had a greater understanding of mathematics and were more confident in learning the subject following their first undergraduate mathematics education unit. Using Spearman’s rho correlation coefficient, a strong positive correlation between perceptions of understanding and confidence is identified for the individual day and evening groups (Appendix Q), and this is maintained for the combined groups, with a positive correlation coefficient of 0.643, $p < 0.01$ (Table 6.5). In comparing the correlations within the pre and post-teaching questionnaires (Tables 5.5 and 6.5), a strong positive correlation is maintained between perceived levels of understanding and confidence.

Day and evening combined: Correlation of perceived understanding and confidence				
			Understanding	Confidence
Spearman’s rho	Understanding	Correlation Coefficient	1.000	.643**
		Sig. (2-tailed)	.	.000
		N	64	63
	Confidence	Correlation Coefficient	.643**	1.000
		Sig. (2-tailed)	.000	.
		N	63	63
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 6.5: Correlation between perceived understanding and perceived confidence in learning mathematics

Having explored perceptions of levels of understanding and confidence in learning mathematics, questions 4 and 5 were designed to examine whether or not the students perceived any changes in these variables. Question 4 asked the participants to rate their perceptions of comparative understanding of mathematics since completing their first mathematics course. This question used a Likert type scale, from 1 being 'I have a much lower level of understanding in mathematics' to 5 being 'I have a much higher level of understanding in mathematics' (Appendix D). All participants answered this question. In examining the data, no students identified themselves as having lower levels of understanding, and a total of 55/64 (86%) students identified that they had a higher, or much higher, level of understanding in mathematics since completing their first mathematics course as undergraduates (Table 6.6).

Comparative understanding: Crosstabulation					
			Day or eve		Total
			Day	Evening	
Comparison und	Same level of understanding	Count	5	4	9
		% within Day or eve	18.5%	10.8%	14.1%
	Higher level of understanding	Count	17	26	43
		% within Day or eve	63.0%	70.3%	67.2%
	Much higher level of understanding	Count	5	7	12
		% within Day or eve	18.5%	18.9%	18.8%
Total		Count	27	37	64
		% within Day or eve	100.0%	100.0%	100.0%

Table 6.6: Comparative perception of understanding in mathematics

Question 5 examined the perceptions of comparative confidence of mathematics since completing their first mathematics course. A Likert type scale was used, with 1 being 'I have a much lower level of confidence in learning mathematics' to 5 being 'I am much more confident in learning mathematics' (Appendix D). All participants answered this question and no students identified themselves as having lower levels of confidence. In combining the two groups, 53/64 (83%) of students identified themselves as having a ‘higher’ or ‘much higher’ level of confidence in learning mathematics (Table 6.7); however, in comparing the confidence levels of the two groups, the evening group had the highest proportion of students within these categories with 35/37 (95%) students compared to 18/27 (67%) in the day group.

Comparative confidence: Crosstabulation					
			Day or eve		Total
			Day	Evening	
Comparison conf	Same level of confidence	Count	9	2	11
		% within Day or eve	33.3%	5.4%	17.2%
	Higher level of confidence	Count	14	30	44
		% within Day or eve	51.9%	81.1%	68.8%
	Much higher level of confidence	Count	4	5	9
		% within Day or eve	14.8%	13.5%	14.1%
Total		Count	27	37	64
		% within Day or eve	100.0%	100.0%	100.0%

Table 6.7: Comparative perception of confidence in learning mathematics

Earlier I suggested that from analysing the first three questions of the post-teaching questionnaire it appeared that there was an increase in perceived levels of understanding and confidence in learning mathematics. The analysis of questions 4 and 5 are consistent with these findings, as over 80% of students identified a comparative increase in their levels of understanding and confidence having completed their first mathematics course as undergraduates. I also established a strong positive correlation between perceived understanding and confidence levels (Table 6.5); however, in exploring the correlations between the comparative levels of understanding and confidence the correlation was inconsistent. Using Spearman’s rho correlation coefficient there was a moderate positive correlation between these two variables, positive correlation coefficient of 0.494, $p < 0.01$ (Table 6.8) and the correlation was stronger for the day group than the evening group (Appendix R).

Day and evening combined: Correlation of comparative understanding and confidence				
			Comparison und	Comparison conf
Spearman's rho	Comparison und	Correlation Coefficient	1.000	.494**
		Sig. (2-tailed)	.	.000
		N	64	64
	Comparison conf	Correlation Coefficient	.494**	1.000
		Sig. (2-tailed)	.000	.
		N	64	64
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 6.8: Correlation between comparative understanding and confidence in learning mathematics having completed a unit of mathematics

Question 6 asked the students to rate a range of potential factors that may have influenced their learning of mathematics and they were asked to rate these influences using a Likert scale. As the two groups demonstrated similar responses (Appendix S) a summary of the combined groups is presented in Table 6.9.

	1 Strong negative influence	2 Negative influence	3 No influence	4 Positive influence	5 Strong positive influence
Attendance at sessions	0	0	3 (5%)	16 (25%)	45 (70%)
Teaching	0	0	0	24 (37.5%)	40 (62.5%)
Other students	0	1 (2%)	4 (6%)	47 (73%)	12 (19%)
Tests and exams	1 (2%)	9 (14%)	11 (17%)	31 (48%)	8 (13%)
Online materials	0	0	7 (11%)	41 (64%)	15 (23%)
Discussion boards and blogs	0	2 (3%)	47 (73%)	13 (20%)	0
Websites	0	0	19 (30%)	38 (59%)	5 (8%)
Outside influences	0	1 (2%)	37 (58%)	19 (30%)	2 (3%)
Drop in sessions	0	0	35 (55%)	15 (23%)	1 (2%)
In class discussion	0	1 (2%)	2 (3%)	43 (67%)	17 (27%)
Other (please state):					

Table 6.9: Summary of responses of influencing factors

Attendance and teaching were the highest rated influences in the ‘strong positive’ category, identified by 45 (70%) and 40 (63%) of students respectively. In exploring the positive influences, other students and in class discussions scored most highly; however, in combining both of these categories, teaching remains the highest positive influence overall, identified by all of the students, followed by attendance (61 students, 95%) and in class discussion alongside other students (60 students, 94%).The highest rated negative influence was that of tests and exams, identified by 10 (16%) of the students; however, despite the fact that ‘tests and exams’ were identified as the highest negative influence 39 students (64%) rated this factor as a positive influence. This was the only factor to be rated as having either a clear positive or negative influence. Three factors were identified by over half of the students as having no influence, and these were discussion boards and blogs outside influences and drop in sessions Within the additional comments, six students identified that the drop in sessions were not needed, or were not run at a time that they were able to attend.

6.3 Presentation and analysis of qualitative data

Having examined the quantitative elements of the post-teaching questionnaire, I now turn to the students' qualitative comments, where they were asked to respond to the following:

'Think about your perceptions of learning mathematics over the first course you have completed as undergraduates. Identify any factors (positive or negative) that you think may have affected how you feel about it today. Please give as full an answer as possible'.

59 of the 64 participants responded, with 25/27 comments from the day group and 34/37 from the evening group. As for the previous elements of qualitative data collected for the audit and within the pre-teaching questionnaire, I familiarised myself with the data presented. I constructed a thematic coding system to identify the most common themes identified by the students in affecting how they felt about mathematics and whether these themes were of a positive or negative nature. As for the pre-teaching questionnaire, I used Nvivo to support this process, and in particular to support the identification of common words. This enabled me not only to identify common themes, but to explore comments specifically relating to confidence and understanding, identified here as 'concepts'. Hence the thematic coding was expanded beyond that used for the pre-teaching questionnaire and a summary of the findings is presented in Tables 6.10 and 6.11. An example of the comments and coding are available in Appendix T.

Themes	Day		Evening		Combined			
	Positive	Negative	Positive	Negative	Positive	Negative	Total comments	% comments
Online materials	6	0	3	0	9	0	9	15
Teaching	13	0	21	2	34	2	36	61
Teacher characteristics	2	0	5	0	7	0	7	12
Discussion/working with others	5	0	7	1	12	1	13	22
Practice	5	0	5	0	10	0	10	17
Tests and exams	0	3	0	0	0	3	3	5
Personal perceptions	3	1	8	2	11	3	14	24
Total comments	34	4	49	5	83	9	92	
Percentage of positive influences	90							
Percentage of negative influences	10							
	100							

Table 6.10: Summary of thematic coded responses to narrative comments on the post-teaching questionnaire

Concepts	Day			Evening			Combined totals			
	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	%
Confidence	8	0	3	13	0	4	21	0	7	47
Understanding	6	0	0	11	1	1	17	1	1	32

Table 6.11: Summary of the concepts of confidence and understanding from the narrative comments on the post-teaching questionnaire

In examining the factors affecting the students as undergraduates, the ratio of negative to positive influences was 9 to 83 (close to 1 to 9), maintaining the suggestion that the students are more positive about learning mathematics since embarking on their first undergraduate unit in learning mathematics. Over half of the students identified the effect of the teaching as being the top ranked influence (36/59, 61%), with personal perceptions being ranked second by 14 students (24%) and discussion and working with others ranked as third by 13 students (22%). A range of additional factors was also identified, with the role of practice and the use of online materials being identified as useful influences by a number of students (10 and 9 students respectively). In terms of specific references to confidence and understanding, 21 (36%) students commented on increased confidence and 17 (29%) on increased understanding. Whilst acknowledging a range of potentially influencing factors, I now intend to explore the three top ranking themes in more detail.

6.3.1 Theme 1: Teaching

36 of the 92 comments related to teaching, and the identification of this as the highest rated influence on learning mathematics is consistent with the findings from question 6 (Table 6.9). In analysing the students' comments, there were a number of sub-themes identified within this category, and a further 7 students (12%) also commented on the characteristics of the teacher.

In terms of teaching, 25 of the 36 students who identified this as an influencing factor, made specific reference to the process of teaching mathematics, referring to the step by step break-down of methods, clear explanations and modelling techniques. This was reflected in comments such as 'The teaching has been broken down the way each element is worked out, and this has made me have a clearer understanding of areas of mathematics that I have previously worried about or struggle with' and 'Being able to see correct modelling of working out and reaching answers'. Five students commented on the pace of the teaching sessions, with two students identifying that they felt that they already had a good understanding of mathematics and that the pace for them was too slow. Other individual comments referred to valuing the time given to practice in class and the links between the methods used within the teaching sessions and how this related to the teaching of mathematics in the context of their own jobs.

Alongside the comments on teaching, seven students also commented on the characteristics of the teacher. For example, 'A steady pace that is not too fast with a personal touch when needed has been a huge positive'. Another student comments on the usefulness of a step by step breakdown when teaching, and then added, 'Also, I am not afraid to ask questions about things I don't understand as they are explained without making you feel silly (even if you may feel it for asking)'. Those who commented on the characteristics of the teacher also commented on the teaching, linking these two factors through their comments.

6.3.2 Theme 2: Personal Perceptions

Personal perceptions were not listed as an option for question 6, yet there were comments relating to this factor from just under a quarter of the students who responded (14/59). Comments within this theme related to personal views of mathematics related to the course, and included seven students who found mathematics enjoyable and identified that the course endorsed their levels of understanding of mathematics. For example, one student indentified that 'I have always enjoyed mathematics and undertaking this module has cemented and enhanced my learning and teaching of mathematics'. Four students specifically identified that they realised that they already knew quite a lot of mathematics and expressed surprise at enjoying the subject, evidenced in comments such as, 'Mathematics has never been a strong point, but through doing this unit I have realised that I am better than I thought! It has been challenging, but enjoyable'.

Three students felt limited by their personal perceptions and their ability to remember things. One student, in particular, commented on her lack of prior knowledge being an affecting factor: 'I feel overwhelmed by the amount I have to learn, due to my lack of understanding in the first place'.

6.3.3 Theme 3: Discussion and working with others

One fifth of the students identified the value of discussion and working with others as a positive experience, and comments within this theme in the main related to being able to verbalise understanding through talking with others. This was endorsed with comments such as 'Being able to talk through answers and verbalise meanings has helped me,' and 'Through discussion with peers on the course I feel more confident about learning mathematics'. Comments also related to feeling supported by peers. Two students commented on being asked to sit with different students each week, one identifying this as a positive experience, and the other feeling uncomfortable.

6.4 Summary

The purpose of the post-teaching questionnaire was to provide an initial exploration of research questions three, four and five (Chapter 3.2). I will now explore these findings in relation to the research questions.

RQ3: Is there a change in the students' perceptions of learning mathematics after their first undergraduate mathematics education course?

The comparison of the first three questions from the pre and post-teaching questionnaires demonstrated that there had been a change in the students' perceptions in learning mathematics since completing their first undergraduate mathematics education course. This was evidenced in several ways; Firstly, the reversal of the choice of negative to positive words from 2 to1 in the pre-teaching questionnaire to 1 to 2 in the post-teaching questionnaire showed a more positive attitude towards mathematics overall. Supporting this there was an increase of 27 percentage points in those identifying themselves as having a 'good' or 'very good' level of understanding in mathematics (Tables 5.3 and 6.3) and an increase of 23 percentage points of those identifying themselves as being 'confident' or 'very confident' in learning mathematics (Tables 5.4 and 6.4). Further evidence from questions 4 and 5 supported these findings, demonstrating that 86% of students identified themselves as having a 'higher' or 'much higher' level of understanding of mathematics (Table 6.6) and 83% having a 'higher' or 'much higher' level of confidence. (Table 6.7). These factors demonstrate that there was a change in the perceptions of the students on completion of their first mathematics education unit as undergraduates, with students identifying that they felt more positive, more confident and had a higher level of understanding in the subject.

RQ4: What factors are identified that affect how a student feels about learning mathematics as an undergraduate?

Teaching was identified by all of the students as having the highest positive influence on learning mathematics (Table 6.9) and this was endorsed further within the narrative responses (Table 6.10). Having clear explanations and modelling techniques, alongside a step-by- step breakdown of methods were identified as having a positive effect on learning mathematics. These findings are consistent with those who identify that the process of teaching mathematics as key to supporting those who are learning mathematics, and in particular the role of making connections between one aspect of mathematics and another (Skemp, 1971; Askew et al, 1997; Klinger, 2011). Related to this, there was also discussion regarding the characteristics of the teacher, in making the students feel comfortable in their learning environment, similar to the findings of Tobias (1993), Marikyan (2009) and Welder and Champion (2011). A point to note here is that these findings are consistent with the pre-teaching questionnaire where the role of the teacher was the top ranking influence (Table 5.9)

The role of in-class discussion was identified by 60 of the students (93%) as a positive influence in affecting how they felt about learning mathematics (Table 6.9) and was also identified as the third ranking influence through the students' qualitative responses. This is similar to the findings of those exploring the effective teaching of mathematics, where the role of discussion and group work is consistently identified as a factor supporting learning (Ashun & Reinink, 2009; Askew, Rhodes, Brown, Wiliam, & Johnson, 1997; Gresham, 2007; Wittgenstein, 1978).

Other factors identified within the quantitative questions and also the narrative responses included the role of online materials and websites (Table 6.9 and 6.10). This can be further linked to the students' identification of the need to practice the work covered within teaching sessions (Table 6.10). Although students identified attendance as the second most important factor in influencing their learning of mathematics in Q 6 (Table 6.9), it was not discussed within the qualitative comments.

The strategies identified at this point have all been external factors; however, 'Personal Perceptions' was the second most common theme identified by the students as affecting how their learning of mathematics (Table 6.10). Factors identified within this theme included enjoyment of mathematics, the endorsement of understanding and personal limitations. This is consistent with the second theme identified within the pre-teaching questionnaire narrative discussions and maintains the suggestion that how a person feels about mathematics may affect their ability to understand it (Bekdemir, 2010; Buxton, 1981; Tobias, 1993).

RQ5: Are there any perceived strategies that might support students in learning mathematics?

With negative perceptions of mathematics and low levels of confidence having been identified earlier as symptoms of mathematics anxiety (Boaler, 2009; Evans, 2002; Gough, 1954; Tobias, 1993) it is possible to see that there has been a decrease in these 'symptoms' within the sample of students who took part in the study. In examining the factors the students identified as affecting their learning of mathematics, I have identified external several factors which might potentially support students in learning mathematics; including the role of the teacher, discussion and working with others and the use of online materials. However, these themes, alongside the role of personal perceptions, needed further exploration and this was the purpose of the focus group discussions to be presented and discussed in Chapter 7.

6.5 Next steps

The post-teaching questionnaire provided data to support discussions regarding research questions three, four and five, demonstrating that the students had a more positive view towards learning mathematics and that there were a number of factors that may have supported this change in perception. With the suggestion that for a number of students there had been a decrease in their anxiety in learning mathematics this led to the final stage of the research, which was designed to explore these factors in more depth. Focus group discussions were planned and carried out, and the results of these will be presented and analysed in the next section.

Section 7: Presentation and Analysis of Focus Group Discussions

7.1 Introduction

In order to explore the students' perceptions of mathematics on completion of their first mathematics education course as undergraduates, the previous section focussed on the presentation and analysis of the data collected from the post-teaching questionnaire. I was able to establish that a greater proportion of students identified a positive, rather than negative view of learning mathematics (2/3) and that this had been a reversal of their perceptions prior to the start of the course. I have identified a number of factors which the students perceived to have affected their learning of mathematics, including the teaching, the effect of the teacher, the use of discussion and personal perceptions. I also suggest that in decreasing the 'symptoms' of mathematics anxiety, the factors the students identified as affecting their perceptions of learning mathematics may have affected this reduction in anxiety (Chapter 6.4). In this section I plan to use this information to construct a template code against which my final aspects of data collection, the focus group discussions, may be analysed.

In June 2012 ten students took part in focus group discussions, where the aim was to probe more deeply into the students' perceptions regarding the initially identified factors affecting the learning of mathematics. In order to identify the students to be involved in the focus groups, the students who made the greatest progress between their audit data and the end of course test were invited to participate. Ten of these students were available to take part and these were and were organised in two focus groups of four students and one of two. The focus group discussions took place during the second week in June 2012. The purpose of this section is to present and analyse the data from these discussions. The specific objectives are as follows:

- To identify the specialist sample of students who participated in the focus group discussions.
- To identify the process of template coding for analysis of the focus group discussions
- To present and analyse the data collected from the student activities and discussions within the focus groups.
- To compare and contrast the findings of the focus group discussions with the post-teaching questionnaire
- To consider the findings of the focus group discussions in light of research questions three, four and five.

7.2 Identification of the specialist sample group

As the students had completed their pre and post-teaching questionnaires anonymously, I had to explore the measures available to me in identifying those for whom there may have been a change in perceptions towards learning mathematics. My rationale for inviting students to be a part of the focus group was based on the previously identified links between low confidence and performance; therefore I identified those students who had made the most progress between their pre-course audit and the end of course test (Chapter 3.4.2). Initial analysis of the audit and test scores showed that there were greater increases in scores for the evening group, and due to the high range in scores the median was used to establish this difference: day group: median +10% difference, evening group: +15.5% difference (Table 7.1).

Report							
Difference between audit score and test score							
Day or Eve	Mean	N	Std. Deviation	Minimum	Maximum	Range	Median
Day group	10.68	34	12.497	-10	40	50	10.00
Evening group	17.35	40	14.038	-6	66	72	15.50
Total	14.28	74	13.678	-10	66	76	14.00

Table 7.1: Percentage differences between audit and test scores

I initially identified those students who made a greater rate of progress than the median scores for their group and they were invited to take part in the focus group discussions. Appendix V shows the rates of progress for the two groups, the sample invited to participate and those who identified that they would be willing to take part. The statistics for the individual focus groups can been seen in Table 7.2.

Gender	**Age**	**Audit Score 2011 (%)**	**Confidence Score 2011 (%)**	**Test Score 2012 (%)**	**Percentage point difference between audit and test score**
Focus Group 1 (Evening group students)					
F	32	18	0	43	25
M	38	60	30	85	25
F	33	58	45	82	24
F	20	46	15	83	37
Focus Group 2 (Day group students)					
F	38	60	50	87	27
F	43	58	65	86	28
F	44	74	30	90	16
F	31	84	68	99	15
Focus Group 3 (Evening group students)					
F	36	46	20	79	33
F	30	8	10	74	66

Table 7.2: Focus Group Background Data

In order to establish the appropriateness of the specialist sample group, I compared the audit and test data, alongside the differences between these two tests with the scores of those within the sample group:

Report			
	Audit Percentage score	February 2012 test	Percentage point difference
Mean	62.76	77.31	14.54
N	74	74	74
Std. Deviation	19.798	14.545	13.860
Median	64.00	79.00	14.50

Table 7.3: Mean scores for the audit, tests and differences

Within the audit scores of the sample group, eight out of ten of the students scored below the combined group mean of 63% and seven students had a lower confidence rating than the mean confidence score of 45% (Graph 4.2); this identified a sample with potentially lower confidence and attainment than the rest of the group. When examining the percentage scores of the test, eight of the ten students scored greater than the mean test score of 77% and nine of the ten students in the sample group made a greater rate of progress than the mean rate of 15% for the combined groups. These results therefore might suggest that the students identified for the sample group fell within the category of increased confidence and attainment in mathematics and hence there was the possibility that their anxiety had lessened. This therefore demonstrated that the students were an appropriate sample for the focus group discussions.

7.3 Template Coding

Analysis of the qualitative data from the audits, pre-teaching and post-teaching questionnaires was through the use of thematic coding, where a number of factors that potentially affected how students felt about learning mathematics were identified. As advised by Robson (2011), these themes arose from my interaction with the data and were reviewed by colleagues to support the process of inter-rater reliability (Chapter 3.6). As the purpose of the focus group discussions was to probe more deeply into students' perceptions of learning mathematics, I realised that the themes I aimed to explore further were already established and hence I needed to consider my approach to analysis of these discussions. In examining the data collected from the audits and questionnaires, I had allowed themes to emerge from the data (a bottom up approach), whereas my intention now was to use these identified themes (or templates) with which to examine students' views more deeply (Newby, 2010).

To analyse the focus group discussions I considered King's (2004) position in regards to template analysis, whereby the researcher produces a list of codes against which qualitative data can be analysed. He suggests that this approach may be used to support a constructivist position, whereby themes are constructed through a range of interpretations of different aspects of data. In order to identify the themes against which I wished to code the data collected from the focus group discussions, I used a priori knowledge based on reasoning from the literature I had read and the data I had collected to this point (Ernest, 1998). These themes are identified in Table 7.4 and those identified more than once are highlighted (green for identification in all four data aspects, yellow for three and orange for two). This was my starting point for creating a set of initial template codes against which to analyse my final set of data (Table 7.5).

Factors affecting how adults feel about learning mathematics			
Literature Review	Audit	Pre-teaching questionnaire	Post-teaching questionnaire
Teacher/Teaching - Personal characteristics of teacher - Pedagogical techniques - Constructivism - Connectivism	Teacher/teaching - Lack of guidance from teacher	Teacher/teaching - Supportive – encouraging, enthusiastic, helpful, understanding, nurturing - Unsupportive - lack of encouragement, lack of support - Lack of subject knowledge - Pedagogy – explanation, pace	Teaching/teacher - Pedagogy – modelling, clear explanations, step by step breakdown of methods - Pace of sessions - Practice time in class - Characteristics of teacher
Role of others - Constructivism – group work, discussion, social activity - Parents - Peers - Made to feel empowered or humiliated	Role of others - Made to feel a failure/scared - Support at home - Effect of peers		Role of others - Discussion with peers – verbalise understanding - Support of others - Uncomfortable moving around at times
Organisation of mathematics - Transitional arrangements - Placement in sets/groups		Organisation of mathematics - Setting arrangements limiting development - Setting arrangements leading to an ability to achieve	
Realism of mathematics - Unrelated to everyday life - Need to make mathematics 'real'			
Personal perceptions - Self defined beliefs as limiting or empowering (fixed and growth mindsets)	Personal perceptions - Scared of the subject - Strong emotions surrounding mathematics - Identified need to improve - Difficult subject - Confidence, or lack of	Personal perceptions - Interest, enjoyment - Difficult subject that cannot be done - Need for personal practice - Lack of confidence - Embarrassment	Personal perceptions - Enjoyment - Challenging, but enjoyable - Overwhelming - Limited by own understanding
		Other - Attendance	Other - Attendance

Table 7.4: Identification of themes from the literature review, audit, pre-teaching questionnaire and post-teaching questionnaire.

Template 1: Teaching (TG)
Template 2: Teacher (TR)
Template 3: Personal Perceptions (PP)
Template 4: Role of others (R)
Template 5: Setting arrangements (S)
Template 6: Other (Ot)

Table 7.5: Initial template codes

Having identified five key themes for my templates, I was able to identify different strands and then sub-strands related to each of these templates and code these in readiness for the analysis of the focus group discussions (Table 7.6). Silverman (2005) warns against premature theory construction, whereby the analysis of research data may provide only generalised themes. Similarly, Gibson (2010) identifies that in using an a priori approach to analysis the researcher must be careful not to ignore additional concepts that may appear outside such knowledge. I was therefore mindful that although I intended to examine the data against specified templates, I also needed to be open to the possibility that there may be findings that were additional to these. Hence, my plan was to analyse the focus group discussion data using the identified templates and then review the data further with the aim of ensuring that additional concepts would not be ignored. In light of this, it was noted that the template strands needed refining as they data was explored. The initial template strands are identified in black, with the refinements in red.

Template	Strands	Sub-strands
Teaching (TG)	TG1: Pedagogy TG2: Pace TG3: Subject knowledge TG4: Planning	TG1a: Demonstration and modelling TG1b: Clear explanations TG1c: Breakdown of methods TG1d: Range of strategies TG1e: Related topics TG2a: Appropriate pace TG2b: Inappropriate pace TG2c: Time for practice in session TG3a: Good subject knowledge TG3b: Poor subject knowledge TG3c: Provision of practice materials TG3d: Links to online resources TG4a: Well planned teaching TG4b: Poorly planned teaching
Teacher (TR)	TR1: Personal characteristics TR2: Nature of support TR3: Subject knowledge	TR1a: Patience TR1b: Humour TR1c: Enthusiasm TR1d: Non-judgemental TR1e: Approachable TR2a: Encouraging TR2b: Not encouraging TR3a: Good subject knowledge TR3b: Poor subject knowledge
Personal perceptions (PP)	PP1: Negative emotions PP2: Positive emotions PP3: Mindset PP4: Practice PP5: Personal circumstances	PP1a: Fear PP1b: Struggle PP1c: Unconfident PP2a: Confident PP2b: Enjoyment P2c: Interest PP3a: 'Can do' attitude PP3b: 'Cannot do' attitude PP5a: As a limitation PP5b: As a support
Role of others (R)	R1: Discussion/group work R2: Nature of support R3: Influence on emotion	R1a: Support understanding R1b: Verbalise understanding R1c: Threat to confidence R2a: Supportive role of other R2b: Lack of support of others R3a: Increased confidence R3b: Fearful and nervous
Setting arrangements (S)	S1: Limitation S2: Empowerment	S1a: Inappropriate level of work S1b: Demoralised S1c: Restricted in grades S2a: Appropriate level of work S2b: Enabled achievement
Other (Ot)	O1: Attendance	

Table 7.6: Template Strands for Analysis of Focus Groups

7.4 Presentation and analysis of focus group activities

7.4.1 Activity 1: To gain an overview of how the students felt about mathematics

The purpose of this first activity was to explore the students' current feelings regarding mathematics. The ten words from question one of the pre and post-teaching questionnaires were shown to the students, and they were then asked how they felt about mathematics at that point in time, using the words as prompts:

> Strong, weak, fear, interest, easy, confident, unconfident, struggle, enjoy, difficult

Initial analysis involved identifying the frequency that the words were used to allow a comparison between the full sample of students within the post teaching questionnaire and the sample group of students involved in the focus group discussions:

Words listed	Frequency spoken			
	Focus Group 1	Focus Group 2	Focus Group 3	Totals
P2a Confident (more)	3	2	2	7
P2d Strong	1	1	0	2
P2b Enjoy	4	3	1	8
P2c Interest	2	0	3	5
P1b Struggle	4	0	0	4
P1a Fear	2	0	1	3
P1c Unconfident	0	0	2	2

Table 7.7: Summary of word frequency in discussion 1

The students identified feelings that were consistent within the Q1 of the post teaching questionnaire, where interest, enjoyment and confidence were the top three positive emotions. Where students identified being confident, this was often rationalised by identifying a measure of being ‘more’ confident. In examining the ratio of negative to positive vocabulary, this is also consistent with the post-teaching questionnaire, with the ratio of 9 to 22 remaining close to 1 to 2 . However, the purpose of the focus groups was to probe more deeply into the students’ perceptions regarding learning mathematics, and hence I looked beyond the quantitative elements of the data to examine the discussions in more detail. To allow for consistency in tracking the discussions, female students are identified as students F1 to F9 and the male student as student M1.

Within focus group one, student F2 dominated the discussion, identifying that although she was more confident than before the unit, she still felt afraid of getting something wrong in mathematics, and believed that fear would always remain with her: ‘I still have a fear of getting something wrong and being shouted at and I think that will always stay with me from when I was at school, always.’ She identified mathematics as a struggle and that it was hard to remember aspects of mathematics, having to revisit concepts numerous times in order to retain them. However, when student F1 suggested that it was interesting to learn about how to teach children, student F2 agreed that she felt more confident to explain methods to the children she worked with at Key Stage 1. The other two students within this group discussed their improvements, with student F3 identifying these in areas that were previously a struggle, specifically identifying fractions and percentages. The only male student (M1) to take part in the discussions commented, ‘I agree. I struggle as well, but at the same time I enjoy the struggle!’

Within the second focus group, two students (F6 and F4) contributed most to the discussion, with student F6 leading the comments and the other students making additional comments. Initial discussions focussed on increased confidence and enjoyment, exemplified by student F6 when stating, ‘I actually enjoy learning maths now. Before it was fear, that was top of the list, but seeing that I can do something involving maths has now given me confidence and then leads on to enjoying trying to do it.’ Continued discussion focussed on specific aspects of learning mathematics, with student F4 identifying that learning ‘up to date methods’ regarding place value and decimals helped, and student F5 agreeing that the concepts were much easier than before. All of the students agreed that they felt more confident, interested in learning mathematics and expressed some level of enjoyment; however, despite this, there was some discussion about the challenges, including when interpreting data and, in particular, where problems were set in the context of words and not numbers.

Both students in the third focus group identified that they felt more confident and found mathematics more interesting than they had done previously. Alongside this, both also expressed nervousness as to whether they would remain confident and would meet the requirements of the following year, exemplified by student F8: ‘I feel a lot more confident with maths and find it a lot more interesting. Still, I think next year I’m going to find hard and will probably go back to being unconfident’. The students also briefly discussed the methods used, and in how the way mathematics was broken down made it easier to understand.

In utilising the Template Strands (Table 7.6) to support analysis, these discussions fell within two of the strand areas, those of Personal Perceptions (PP) and Teaching - Pedagogy (TG1). In terms of personal perceptions, the discussions focussed around the positive and negative language (PP1 and PP2) identified from the pre and post teaching questionnaires; however, consideration might also be given to PP3 regarding Mindset. In the case of student F2, several comments related to her concerns about being able to ‘do’ mathematics, and although the discussions prompted her to identify some positive aspects of mathematics, her final comment within this activity suggested a possible self-limitation: ‘For me, I have to do things numerous times before it sits there and stays there, so if I only do it three or four times, by the following week I’ve forgotten it. That’s just me.’ Personal limitations were also expressed by students F8 and F9 who both suggested that they may not be able to do the mathematics within the next unit, possible evidence of a ‘can’t do’ attitude amongst within some of the students (PP3b); however, there were also suggestions of a ‘can-do’ attitude (PP3a) from student F6, who identified increased confidence and enjoyment in being able to do mathematics and from students M1 and F7, who expressed enjoyment within the challenge of mathematics.

With regards to the Template Strand related to pedagogy (TG1c), some mention was made by students F1 and F2 relating to understanding how to teach aspects of mathematics. Additional comments focussed on introducing up to date methods (student F4) and the breakdown of methods (students F8 and F9) were touched upon. However, discussions in this area were not extended and were explored in more detail in later discussions.

7.4.2 Activity 2: To explore the factors identified from question 6 in the post-teaching questionnaire on influences in learning mathematics as adults

The eleven factors from Q6 from the post teaching questionnaire, where students were asked to rate their levels of influence in learning mathematics, were placed in front of the groups in the form of flashcards, and students were asked to postion them in order from most positive to least positive influence:

Attendance at sessions, teaching, other students, tests and exams, online materials, teacher, discussion boards and blogs, websites, outside influences, drop in sessions, in class discussion

The aims of this activity were to identify whether there was any consistency between the post-teaching questionnaire and the focus group findings, and to explore students' perceptions identified within their discussions. The focus groups positioned their cards from most to least positive influences and these can be seen in Table 7.8.

Position of cards	**Focus Group 1**	**Focus Group 2**	**Focus Group 3**
1	Teacher Teaching	Attendance at sessions	Teacher Teaching
2	In-class discussion Other students Attendance at sessions	Teacher Teaching	Online materials Websites
3	Online materials Outside influences	Online materials	In-class discussion Other students Attendance at sessions
4	Websites Drop in sessions Tests and exams	Websites Tests and exams	Tests and exams Outside influences
5	Discussion boards and blogs	In class discussion Other students	
6		Outside influences Drop in sessions Discussion boards and blogs	
Not used			Drop in sessions Discussion boards and blogs

Table 7.8: Summary of focus group influences for Activity 2

As within the first activity, the discussions within focus group one were mainly led by student F2 (16 comments), with student M1 providing the majority of additional responses (8 comments). There was limited input from the other two students in terms of discussion (6 additional comments), although all contributed to the placement of the flashcards. Remarks initially centred on the positioning of the cards, which prompted discussion regarding the different themes presented. 'The 'teacher' and 'teaching' were immediately placed at the top of the list, with the students identifying the enthusiasm of the teacher and the way 'things' were broken down with examples to see how mathematics was 'done' as positive influences. The role of discussion and other students were linked in that they referred to being able to see how others had carried something out and in being able to work with others as positive: 'A lot of the time you saw everyone else say, 'Oh, that's how you did it. I did it this way," or that way. That was quite nice to see.' All of the students contributed to the discussion regarding online materials, and identified the usefulness of the homework posted on their online BREO site each week and the use of the BBC Bitesize site, for which there was a direct link from BREO. Some consideration was also given to the availability of the session materials online: 'BREO was really useful. I still go back to it, the breakdown of everything on the slides'. There was no discussion relating to the cards placed at the bottom of the list.

Within focus group two, discussions were more balanced, and although led by students F5 and F7, contributions were made by all students within discussions regarding the different themes. An early decision was made regarding attendance as being the most important influence, with student F5 identifying that, 'Attending sessions was paramount'. Students returned to this theme later in the discussion, and reiterated the need for attendance and missing a session would mean that they would be '*lost'.* The discussion regarding the 'teacher' and 'teaching' was brief, and a decision was quickly made to put these in second place, with students referring to the teacher in making sure that the students were clear before moving on and having good teaching. Similarly, the use of online materials was briefly discussed and it was agreed that, 'The use of homework online was vital. Just being able to consolidate it', led to 'online materials' being identified as the third influence.

The main conversation within this group was the one focussed on 'in class discussion' where there were mixed feelings. Student F7 felt that discussion helped others, but not her; however, student F5 identified that it was a higher order skill to be able to explain to others and that it was a positive rather than a negative activity. She also identified that it made her feel as if she was not alone: 'Maybe asking questions you were a bit inhibited to ask yourself if someone else doesn't get it you think, it's not only me. Sometimes I don't want to ask because I might be the only one who doesn't get it'. The other two students in the group agreed that discussing with others could be supportive. In terms of those themes identified within the lower sections, there was little conversation regarding these, other than discussion, and students' brief comments allowed them to place the cards where they felt appropriate.

For focus group three, both students within the group contributed to the conversation. They quickly identified the 'teacher' and 'teaching' as being linked and placed them as the top influences, with little discussion regarding them. Online materials, including homework and websites were found as helpful. When in class discussion was identified, the students suggested that it was good to be able to hear what others were thinking and to see the methods that were being used. The main conversation within this group was the discussion regarding 'tests and exams, with student F8 identifying that she was 'Petrified! The pressure of it was the most intense I have felt in ages!' However, student F9 suggested that she preferred being tested than doing assignments as this is where she panicked more. The students did not feel able to comment on discussion boards and blogs as they had not used them.

In comparison with the post-teaching questionnaire (Table 6.9) ‘teaching’ and ‘attendance’ maintained their positions within the top two positive influences. However, within the post-teaching questionnaire, the role of ‘in-class discussion’ was identified as a positive influence by over 90% of the sample, and this was consistent with the discussions within focus groups one and three, although not for all students within focus group two. Drop in sessions alongside discussion boards and blogs were the lowest ranked positive influences within the post-teaching questionnaire, consistent with the findings from the focus groups.

In using the Template Strands (Table 7.3) to support analysis, all of the strands, with the exception of Setting Arrangements, were identified; however, more specific discussions were made in relation to the Teaching, Personal Perceptions and Role of Others. With regards to Teaching – Pedagogy (TG1) positive reference was made to the break down of methods (TG1c) and the role of clarity in explanations (TG1b). All three focus groups made reference to the provision of homework and access to online materials as positive, linking the provision of materials within Teaching (TG3c) and the need for practice within Personal Perceptions (PP4).

All three groups identified the strand related to the Role of Others (R) when focussing on the role of discussion and group work and students F1, F5, F7 and F8 identified that discussion helped to verbalise understanding (R1a, b). Students in focus group two extended their discussions within this theme, identifying that discussion provided support for others (R2a), but that it did not necessarily provide support for the person giving explanation (R2b). Students F5 and F6 identified an increase in their sense of achievement when explaining to others (R3a).

Within the post-teaching questionnaire ‘teaching’ was identified as the top positive influence in learning mathematics (Tables 6.9 and 6.10), maintaining a consistency with the findings of the focus groups where two of the groups rate this as one of the top influences and the other rating this as the second highest influence. As the discussions maintained a link between the teacher and the teaching, activity three was designed to probe more deeply into these differences.

7.4.3 Activity 3: To explore the students’ perceptions of teaching as a factor in influencing how people feel about learning mathematics.

‘Teaching’ had been the only theme identified by all students within the post teaching questionnaire, and therefore this activity was designed to probe more deeply into why this might be so. Leading on from Activity 2, students were told that within the post-teaching questionnaire, ‘teaching’ was the only factor identified by all students as affecting how they learn about mathematics, and that within this there seemed to two strands, ‘the teacher’ and ‘the teaching’. Students were given a piece of flip chart paper and asked to identify the characteristics under the headings of ‘the teacher’ and ‘the teaching’. They were encouraged to discuss these strands and identify both positive and negative features.

Within focus group one, all students contributed to the discussion, although contributions from student F3 remained limited. Initial conversations related to the ‘teacher’, focussing on the need for good subject knowledge and on nurturing type characteristics, such as patience and being approachable. The remainder of the discussion related to the ‘teaching’ and focussed more on how the sessions were taught, including the way the topics were related and built upon each other:

M	It’s kind of related, the topics, so we didn’t jump from one thing to something completely different
F3	It started off with the basics and then it built up.

Reference was also made to the pace of the teaching sessions, with student F2 identifying that ‘We worked at our own pace within the group ... if we didn’t get it, we went over it again. I liked that’. However, the same student later identified that towards the end of the teaching session she felt overloaded. The provision of homework was identified as a positive and linked to the need for personal practice. The final element that the students related to the teaching was the relaxed atmosphere within the teaching sessions, with one student relating this to the provision of discussion time, and another to the mixing of groups, with students F1 and M suggesting that this provided peer support.

At one point within the discussion, the group began to talk about past experiences, questioning whether mathematics was taught differently in their past, or ‘... is it because we weren’t listening back then?’ This prompted some discussion regarding whether or not the aspects of mathematics they did not understand in the past were down to their own limitations or that they understood more in current times as they used mathematics more in everyday contexts, which they did not do as children.

In summary, focus group one listed their characteristics related to the teacher and teaching in the following way:

Teacher	Teaching
▪ Subject knowledge ▪ Patience ▪ Non-judgemental ▪ Enthusiasm ▪ Enjoyment ▪ Approachable	▪ Different strategies/approaches ▪ Well planned ▪ Clear – well explained ▪ Opportunities for discussion/questions ▪ Relaxed atmosphere ▪ Homework ▪ Interlinked topics ▪ Suitable pace most of time

Table 7.9: Focus group one: characteristics of ‘teacher’ and ‘teaching’

Within focus group two, students F4 and F5 led the conversations, although all students contributed to the discussions and they began with focussing on the characteristics of the teacher. The need for high expectations and good behaviour management was identified by student F4: ‘Straight away I would have to say expectation. There was high expectation in the class to perform, for everybody in the classroom, the teacher and students’, which was endorsed by students F5 and F6. Additional comments related to the behaviour of the teacher, including using appropriate terminology, having good subject knowledge and using a direct approach in being able to explain things clearly. Some comments related to the personal characteristics of the teacher, with being approachable and having a sense of humour being specifically identified.

In terms of the ‘teaching’, students focussed on how mathematics was taught, with the need for the demonstration of different methods and *‘breaking mathematics down into achievable steps’* (F4) being identified by all four students. Students F4 and F5 also suggested that the use of different teaching techniques, such as the use of the interactive whiteboard, flip chart and visualiser were helpful. Having time to practice within teaching sessions gave students opportunity to ask if they did not understand and this meant that topics could be re-explained and this was later linked to the identification of a '...comfortable pace to learn' (F6) and '... brisk, but well suited to the group' (F4). The final discussion within this activity related to the atmosphere in the classroom, identifying that a relaxed atmosphere meant that the students were not tense; however, students felt that this related both to the teacher and the teaching and could not categorise this under one heading.

At one point, students veered away from the main topics and had a discussion about the positives and negatives of group work. Students F5 and F6 identified that they would be put off in group situations if the others in their group did not have the same 'drive and determination' as them. Student F7 expanded on this, saying that in terms of getting to know others, mixing groups up was a positive, but in terms of comfortable learning they 'hated it'. As a group, the students felt that when they were with like-minded people, group work could be positive, but when not it affected their own focus and had the potential to distract them from the work that they were doing.

The summary of characteristics from focus group two can be seen in Table 7.10

Teacher	Teaching
▪ Expectation ▪ Behaviour management ▪ Assertive ▪ Approachable as person ▪ Subject knowledge ▪ Terminology and clarity	▪ Demonstration and repetition on IWB and flipchart ▪ Teaching techniques ▪ Time to practice ▪ Group discussion ▪ Breaking maths down into achievable steps ▪ Pace- brisk but well suited to the group ▪ Group dynamics could potentially be a barrier
Relaxed atmosphere	

Table 7.10: Focus group two: characteristics of ‘teacher’ and ‘teaching’

The discussions within focus group three explored aspects linked to the teacher relating to how the students were made to feel comfortable. Discussions focussed on the need for the teacher to have good subject knowledge and to be clear in explanations. Also identified were the personal characteristics of the teacher in being approachable and confident, making a link to the effect of the teaching on their ability to work with pupils: ‘If the teacher isn’t confident about what they’re talking about and doesn’t approach it in the right way, then it affects the way you teach it to your pupils.’ In terms of the teaching, the students in focus group three highlighted the need to break the teaching down into steps and having time to practice within teaching sessions giving them time to reflect, practice and apply. Table 7.11 shows the summary of characteristics for this group.

Teacher	Teaching
▪ Clear manner ▪ Made us feel comfortable ▪ We understood mathematical terms ▪ Approachable ▪ Made enjoyable ▪ Knowledgeable about subject	▪ How we were taught ▪ Simple terms ▪ In stages ▪ Time to reflect/practice/apply
Achievable	

Table 7.11: Focus group three: characteristics of ‘teacher’ and ‘teaching’

In terms of utilising the Template Strands to support the analysis of Activity 3, consistencies are identified between the discussions within the focus groups and the qualitative data comments from the post teaching questionnaire identified within Theme 1: Teaching (Chapter 6.3.1). All three focus groups made comments in relation to the strand on Teaching – Pedagogy (TG1), incorporating the need to break mathematics down into manageable steps (TG1c) and using different teaching approaches to make things achievable (TG1d). Two of the groups identified that a pace suited to the needs of the teaching group supported learning (TG2a) and all groups identified the need to have time to practice in teaching sessions as an opportunity to reflect upon and clarify aspects that they were unsure of (TG2c). All of these elements were identified within the qualitative discussions within the post teaching questionnaire.

In terms of the strand relating to the Teacher (TR), all three groups identified the need for the teacher to have good subject knowledge (TR3a) which was not something that was clearly evident within the post-teaching questionnaire. In addition to this, comments relating to the personal characteristics of the teacher were identified by all three groups, and included the roles of patience, humour and enthusiasm (TR1a, b, c) alongside approachability and confidence (TR1e, f) as being supportive. The need for clarity was also identified by two of the groups (TR3c).

The strand focussing on the Role of Others (R) was also explored, particularly in relation to group work (R1) and there were mixed perceptions related to this area. Students in focus group one were positive about the effect of discussion and group work (R1a); however, the students in group two felt less so, suggesting that group dynamics could be a potential barrier to learning (R2b). In comparison to the post-teaching questionnaire, the positive aspects of group work and discussion are consistent, but there was an expansion within the focus group on the more negative aspects of group work that were not clear from the earlier elements of data collection. One factor that was discussed within the groups that students found difficult to place within one category was the need for a ‘relaxed’ learning environment, where students felt comfortable to ask questions and discuss the mathematics within the lesson.

In terms of comparison between the three groups, the key consistent characteristics of the ‘teacher’ and ‘teaching’ area identified in Table 7.12.

Teacher	**Teaching**
▪ Good subject knowledge ▪ Nurturing characteristics ▪ Clarity in use of language and explanation	▪ Clear demonstrations to breakdown methods ▪ Range of teaching strategies ▪ Suitable pace (not too fast or slow) ▪ Time for practice ▪ Opportunities to ask questions

Table 7.12: Summary of characteristics of ‘teacher’ and ‘teaching’

Aspects touched upon within the earlier activities included the role of discussion to support mathematical learning and the effect of personal perceptions. The final activity was designed to probe more deeply into these areas.

7.4.4 Activity 4: To explore additional factors identified within students' comments from the post-teaching questionnaire

Students were told that the two additional main themes identified as factors affecting how the main sample group felt about learning mathematics were 'Discussion' and 'Personal Perceptions'. The focus groups were asked to discuss these two topics within this final activity in relation to what the effect of working with others had on their learning of mathematics and how their personal view of mathematics affected their learning. The aims of this were to probe more deeply into the findings of the post-teaching questionnaire and to identify any similarities and differences between the focus group and the full sample group of students.

Within focus group one, the role of working with others and using discussion was identified as a benefit where students had the opportunity to work with people who they did not normally work with. In doing this, the main benefit identified was that different people explained things in different ways, and that they were able to help each other in sometimes using strategies that were different to the teacher: Student F1 identified 'I sat with somebody who was stronger that I wouldn't necessarily have chosen to sit with and she was a great help because I didn't get it and she broke it down, showed me a bit at a time, like a sub teacher.' This prompted a discussion to which students F3 and M contributed to, endorsing the positives of working with others. In contrast to this, student F2 expressed anxiety at working alongside others, feeling fearful that there may not be someone to help her, or that she would be afraid to ask. As a group, the students compared their past experiences, where discussion was limited or they were expected to work in silence and ‘just get on with it’.

In moving on to personal perceptions regarding mathematics, three of the four students contributed to this discussion, with student F2 identifying that she hated mathematics and had a fear of the subject before she began the course. She also suggested that she was stronger in mathematics now and would present a more positive view to her son than before. Student F1 expressed excitement and enjoyment at studying mathematics. Two of the students, identifying themselves as having English as an Additional Language (EAL), discussed the fact that at times the language of mathematics appeared to be trying to trick them. This led them to discuss issues related to mathematics language and the possibility that this masked their true ability in mathematics, leading to being banded in the wrong GCSE group: ‘Leading up to GCSE. They group you into Foundation tier and Higher tier. Already they’ve decided that’s the route you’re going to go. I think Year 9 they’ve decided that’s the route you’re going to go so they’ve put you into that and you work towards that. And the best grade you can achieve is C basically. That didn’t help, for me.’ A point to note here is that in the UK examination system, students follow either a Foundation tier syllabus, where they have access to grades C to G, or a Higher tier syllabus, when they have access to the range of grades from A to D.

All four students contributed to the discussions within the second group, and the main focus of the role of discussion for this group was on its use for personal clarification and in reinforcing their own learning. They identified that by being given the opportunity to discuss mathematics and support others was encouraging to them. They also suggested that when they were not able to explain something, it helped them to identify the areas that they lacked understanding in.

Student F5 exemplified this in her comment that after explaining some mathematics to another student, ‘It made me feel better thinking I actually did get that, there’s an error I’ve got to look at so I can explain it to somebody else and understand I’ve got to revise that bit.’ In terms of past experiences, the students were not encouraged to talk about mathematics or ask questions, with the focus being on being able to use a specific method rather than understanding, and all four students commented that they were made to feel silly for asking questions and one student ‘wouldn’t have dared ask’.

With regards to personal perceptions, there was an identification of both positive and negative feelings towards mathematics, with student F5 feeling sick and other students identifying emotions being linked to feeling scared and lacking enjoyment in school. Student F4 identified that she enjoyed mathematics and was not worried about the unit, explaining that what she had learnt built on previous understanding. The other three students expressed surprise in regards to what they already knew: ‘It was there, but I just wasn’t using it or didn’t know I had it.’ One restriction discussed by the group was to do with the issue of being limited by where they had been placed within sets in school and that there was no possibility of them moving outside of the expected limits place upon them.

Within focus group three, the discussion explored both positive and negative feelings about working with others. One student felt unnerved and lacked confidence in being able to contribute to discussion, whereas the other saw group work as providing a support network where she could gain guidance from others, placing everyone on the same level; however, the same student suggested that she would contribute in small group discussion, but not in front of the whole class. In terms of past experiences of discussion, student F9 identified that in school ‘You just got on with it. You had a work book. You were always put in tables, you faced the teacher and I just didn't enjoy maths.'

With regards to personal perceptions, both students discussed negative emotions relating to past experiences in mathematics, in terms of lacking enjoyment and feeling anxious. The feelings regarding not being able to do mathematics in front of others also came across. Student F9 identified the effect this had on the rest of her life: 'It affects you when you go out to places, working money out. It has a big effect on the rest of your life if you don't get it right at the beginning'. She linked this to the need for practice, alongside the reality of having time to do so alongside other aspects of her study.

In terms of analysing the data against the Template Codes, consistencies were again established between the post-teaching questionnaire themes and the focus group discussions. Within the template strand relating to the Role of Others (R), students who saw group work as a positive related this to the role of discussion in supporting personal understanding and that of others (R1a) and also in being able to support and encourage peers (R2a), which made them feel as part of the whole group. Two students were less positive about group work suggesting that it could make them 'fearful and nervous' which meant that they did not 'feel at ease' in working with others (R3b).These themes were consistent with the findings within the post-teaching questionnaire.

With regards to Personal Perceptions (PP), three of the students made reference to negative emotions surrounding their views of mathematics, in particular identifying feeling fearful (PP1a) and for one of these students this left a 'block' on learning mathematics, which could be linked to the Mindset strand connected to a 'can't do' attitude (PP3b). However, others expressed enjoyment and excitement about being able to do mathematics (PP2b), with one student identifying a sense of empowerment (a 'can do' attitude, PP3a): 'If I can understand mathematics and do that now, then that's my weakest subject and I can do anything the college throws at me!'. Of those commenting about setting arrangements, all suggested that setting had restricted their potential (S1d). In terms of comparison with the post-teaching questionnaire, there was a consistency with the positive aspects of enjoyment of mathematics, and being able to do more than was originally thought; however, negative perceptions in terms of being fearful and restricted in learning mathematics, were expressed within the focus groups more clearly than within the post-teaching questionnaires. Reference to limitations within setting arrangements was consistent with the findings of the pre-teaching questionnaire (Table 5.9) and analysis of qualitative comments (Chapter 5.3).

7.5 Summary

The purpose of the focus group discussions was to probe more deeply into students' perceptions in learning mathematics, and the possible factors that might help students overcome associated anxiety. The template strands (Table 7.6) were used to support analysis of the focus groups and the strands identified within each area of discussion and are summarised in Table 7.13.

Activity	Template	Strand
1	Personal Perceptions (PP)	PP1: Negative emotions PP2: Positive emotions PP3L Mindset
	Teaching (TG)	TG1: Pedagogy
2	Teaching (TG)	TG1: Pedagogy TG3: Subject Knowledge
	Personal Perceptions (PP)	PP4: Practice
	Role of others (R)	R1: Discussion/group work R2: Nature of support R3: Influence on emotion
3	Teaching (TG)	TG1: Pedagogy TG2: Pace
	Teacher (TR)	TR1: Personal characteristics TR2: Subject knowledge
	Role of others (R)	R1: Discussion/group work R2: Nature of support
4	Role of other (R)	R1: Discussion/group work R2: Nature of support R3: Influence on emotions
	Personal Perceptions (PP)	PP1: Negative emotions PP2: Positive emotions PP3: Mindset
	Setting arrangements (S)	S1: Limitation

Table 7.13: Summary of template strands identified within the focus group activities

Identification of these strands enabled an analysis of the focus group discussions against research questions three, four and five:

RQ3: Is there a change in the students' perceptions of learning mathematics after their first undergraduate mathematics education course?

I earlier identified a negative correlation between mathematics anxiety and mathematical performance suggesting that low performance in mathematics correlated with lower levels confidence and higher levels of anxiety (Hembree, 1990; Ma, 1999; Brady & Bowd, 2005). Comparison of the pre and post-teaching questionnaires demonstrated a change in the students' perceptions of learning mathematics, identifying that they felt more positive, more confident and had a higher level of understanding in the subject (Chapter 6.4). The focus group statistics (Tables 7.2 and 7.3) showed that students in the specialist sample group initially demonstrated a lower mean confidence score than that of the full sample group (Tables 4.7 and 7.3) and had a greater mean rate of progress than the whole group (Table 7.3). This group could therefore be identified as a sample in which there had been a potential change in perceptions about learning mathematics and therefore qualified to discuss such changes.

Group statistics from the audit demonstrated that this sample of students had a lower mean confidence rating (33%) than the full sample of students (45%), yet discussions within the focus group activities suggested that all of the students felt more confident having completed their first mathematics unit than before (Focus group activity 1). Continued discussion demonstrated that there was greater interest and enjoyment in mathematics alongside some surprise at what individuals had been able to achieve. Students within all groups identified that some concepts were easier to understand than in previous experiences. Of the ten students, three were more cautious, suggesting that they were unsure as to whether they would continue to be confident when faced with new challenges, and one student maintained that she was fearful of mathematics. These factors would suggest that, in the main, there had been a change in the students' perceptions of learning mathematics, whereby students felt more confident, and expressed greater enjoyment and interest in the subject. It should be noted that for some students, these changes in perception were regarded with some caution.

RQ4: What strategies are identified that affect how a student feels about learning mathematics as an undergraduate?

In earlier discussions it was suggested that the teacher may be the overriding influence on how people feel about learning mathematics (Crook & Briggs, 1991; Bibby, 1999, 2002; Marikyan, 2009; Welder & Champion, 2011) and that the pedagogical techniques the teacher uses are also key factors in influencing perceptions (Brady & Bowd, 2005; Haylock, 2010; Welder and Champion, 2011). Although a number of factors were identified by the students within their discussions, the role of the teacher and teaching were similarly identified by all groups within three of the four activities (Table 7.10). Discussions relating to the teacher were focussed on the personal characteristics of the teacher needing to have good subject knowledge, nurturing characterisitcs (such as enthusiasm and approachability) and to be clear in explanation. Within teaching, students identified that there was a need for clear demonstration and breakdown of methods using a range of strategies. Time for questions and practice within teaching sessions were also considered as important.

The need for practice to support understanding was identified by all groups, and was often related to the provision of online practice materials and the need to consolidate what was covered in the teaching sessions (Table 7.8). Students identified their own role in learning mathematics in that they could improve their understanding by practicing outside of the teaching sessions, relating to the mastery-oriented pattern of learning identified by Dweck (2000), whereby a person takes responsibility for their own learning. However, one student demonstrated more of a helpless-orientated pattern of learning (Dweck, 2000) whereby she felt that she might just not be able to 'do' mathematics (Focus Group one, activity one).

With regard to the role of discussion, Tobias (1993), Marikyan (2009) and Johnston-Wilder and Lee (2010) suggest that its use can be a positive factor in supporting the learning of mathematics. Similar to this, benefits were identified by the focus groups within three of the four activities (Table 7.10) which included the supportive nature of working with others and the role of discussion to reinforce their own learning. However, some were not positive regarding the role of discussion and felt uncomfortable and fearful when discussing in groups, being afraid to voice their views in case they were the only ones who did not understand (focus groups one and three, activities one and three). This is similar to the findings of those who have identified that some find the public nature of doing mathematics in front of peers inhibiting (Ashcraft & Moore, 2009; Bekdemir, 2010; Welder & Champion, 2011). Others felt that peer discussion only supported their learning when working with those who were like minded (focus group two, activity four).

To answer the identified research question, the focus groups identified that there were a number of factors influencing their learning of mathematics as undergraduates, to include the role of the teacher and teaching, time for practice, the role of discussion and the effect of working with others.

RQ5: Are there any perceived strategies that might support students in overcoming mathematics anxiety?

Having earlier identified that the focus groups were an appropriate sample for exploring the area of research focus further, it has earlier been suggested that this sub-group of students may have had decreased anxiety and increased confidence in learning mathematics. In terms of identifying a more positive approach to learning mathematics, students identified several influencing factors identified within the previous research question. As a result of this it may therefore be suggested that within this group of students, the following factors could potentially support students in overcoming mathematics anxiety. Firstly, the need for a teacher with good subject knowledge, nurturing characteristics and clarity in explanations, alongside a good understanding of appropriate pedagogical techniques; Secondly, the use of discussion to support learning, although this needs to be considered in light of those who are fearful of carrying out mathematics in front of others; and thirdly, the students' personal need for practice and consolidation. It is with these considerations in mind that further thought will be given to these factors.

7.6 Next steps

The focus group activities provided data to support discussions regarding research questions three, four and five. Data was analysed with the support of a template constructed from a priori knowledge, and this template was adapted and amended during the process of analysis (Table 7.3). Using this template I was able to identify that there appeared to be a more positive view of learning mathematics within this group of students in comparison to responses within the pre-teaching questionnaires. A number of factors were identified that may have supported this change in perceptions.

Discussions and analysis, up to this point, have focussed on the individual elements of data collection. The purpose of the next section is to compare the different elements of the data collection process and triangulate findings to provide an answer to the research questions identified. Particular attention will be given to the main aim of this research, which was to identify those strategies that might have supported students in learning mathematics.

Chapter 8: Discussion and Conclusions

8.1 Introduction

The past chapters within this project have examined a range of measures to explore adults' perceptions in learning mathematics. This has included reviewing a range of literature within this field (Chapter 2) and the presentation and analysis of four elements of data collection: student audits, pre-teaching questionnaire, post-teaching questionnaires, and focus group discussions (Chapters 4, 5, 6 and 7). Within the analysis of each of these, I have examined how the individual pieces of data have addressed the research questions specified, focussing on any changes in the students' perceptions of learning mathematics during the course of their first year as undergraduates and any strategies that may have been perceived to support them. The purpose of this final chapter is to consider how the data collected as a whole contributes to answering the research questions posed, hence addressing my over-riding research aim:

> To explore adults' perceptions in identifying strategies to support them in learning mathematics as they embark on an undergraduate degree course in Applied Education Studies

In order to do this, I maintain my commitment to triangulate the data in order to corroborate or question my findings (Denscombe, 2010). I had planned that the qualitative elements of the study would be used to explain the quantitative results (Cresswell and Piano Clark, 2011), and this chapter utilises the data collected from the study in this way. Miles and Huberman (1994) advise that qualitative data needs to be reviewed in order to identify common themes and that these can then be used to support the next 'wave' of data collection. It is suggested that the identification of these themes in this way can support the process of generalising in relation to the data collected. With this in mind, this chapter demonstrates that the analysis of the data has been an iterative process, repeatedly returning to the themes identified throughout the difference phases of the research in order to identify strategies that might support adults in learning mathematics.

In terms of the research process as a whole, my original purpose was similar to that stated by Potter (2006) in that I wanted to advance my understanding of the subject in which I worked and contribute to the field of supporting adults in learning mathematics. Having triangulated the findings from my data, I will consider how these findings have advanced my understanding of adults learning mathematics and what implications this may have for my own practice. I will also consider where these findings sit within the field of mathematics education, keeping in mind the limitations of the study.

Therefore, the objectives for this chapter are as follows:

- To review the focus for the research
- To consider the key findings in relation to research questions one to four
- To identify the key themes from the triangulation process in order to identify factors that might affect adults in learning mathematics
- To identify strategies that might in support adults in learning mathematics
- To evaluate the research and consider the limitations of the findings
- To consider the contribution to the field of mathematics education
- To consider the implications for my own practice
- To conclude the research

8.2 Review of research focus

In the early stages of the research, having identified that students were often anxious about learning mathematics when embarking on their undergraduate degree in Applied Education Studies, I initially believed that I would just be exploring issues surrounding mathematics anxiety; however, as the research progressed, my considerations broadened in terms of exploring how the adults I worked with perceived mathematics and how they might be supported in developing their understanding of the subject. Specifically, the literature I reviewed suggested that alongside mathematics anxiety, there were a range of emotions surrounding the learning of mathematics and adults perceptions regarding this area (Crook & Briggs, 1991; Tobias, 1993; Bibby, 2002). It was noted that where adults were more negative about mathematics, this had a direct impact on their performance (Evans, 2002; Ashcraft & Krause, 2007;). Further to this, it was suggested that where adults with negative perceptions were involved in teaching mathematics to children, these perceptions may be passed onto their pupils and that such teachers may lack confidence to teach mathematics effectively (Thompson, 1984; Ball, 1990; Ashcraft & Moore, 2009; Brady & Bowd, 2005; Haylock, 2010). This led me to consider where negative perceptions might originate from and what might be done to overcome such negativity. As a result of this, I constructed five research questions to help guide my research:

- What perceptions do students have regarding learning mathematics before embarking on their first mathematics education course? (RQ1)
- What past factors have affected students' perceptions of learning mathematics? (RQ2)
- Is there a change in the students' perceptions of learning mathematics after their first undergraduate mathematics education course? (RQ3)

- What factors are identified that affect how a student feels about learning mathematics as an undergraduate? (RQ4)
- Are there any perceived strategies that might support students in learning mathematics? (RQ5)

As the research process developed, it became evident that research questions one to four enabled me to identify a range of themes that affected how the adults within the study felt about learning mathematics and the factors that had affected them. The final research question was the key in supporting my over-riding research aim in identifying strategies that might support adults in learning mathematics. Hence this discussion is organised to first triangulate the data in light of the first four research questions and then to use this analysis to support the identification of the key themes that have emerged through this process, therefore addressing the fifth research question and my over-riding research aim.

8.3 Review of research questions one to four

The audit data and the pre-teaching questionnaires were used to explore the first two research questions and the findings from these were compared to identify consistencies or discrepancies between the two sets of data (Chapter 5.4). The post-teaching questionnaires and focus group discussions were designed to explore research questions 3, 4 and 5 and were analysed against the research questions in Sections 6.4 and 7.5. A point to note here is that some discussion also took place regarding past influencing factors within the focus groups discussions, and links can be made to the audit and pre-teaching questionnaire. These discussions will now be further explored, with the aim of triangulating the data to identify strategies that may have supported the students in learning mathematics.

8.3.1 Research Question 1: What perceptions do students have regarding learning mathematics before embarking on their first mathematics education course?

Students demonstrated a more negative rather than positive view of mathematics prior their first undergraduate unit in mathematics education (with ratios close to 2 to 1 negative to positive). This was reflected in the students' confidence ratings within the audit (Table 4.13), the vocabulary choices within the pre-teaching questionnaire (Table 5.2) and perceived levels of understanding and confidence ratings (pre-teaching questionnaire, Tables 5.3 and 5.4). With approximately two thirds of students identifying themselves as feeling negative regarding learning mathematics, the similarities were consistent in that with just 25% of the sample (17/68) having a good, or very good, perceived level of understanding (Table 5.3) and just over one third as having a good, or very good, perceived level of confidence (24/66, Table 5.4), the larger proportions remained in the lower levels of perceived understanding and confidence.

Similarities were found with those who identified a link between performance and confidence in learning mathematics (Evans, 2002, Ashcraft & Krause, 2007). When correlating the students' perceptions of themselves in these areas, a strong positive correlation was identified (Spearman's rho correlation coefficient, positive correlation coefficient of 0.707 $p < 0.01$, Table 5.5).

These discussions demonstrate that in relation to research question one, a larger proportion of students were negative, rather than positive regarding learning mathematics and this was demonstrated within lower levels of confidence and understanding being identified. Supporting these were the students' choices of vocabulary to describe learning mathematics, whereby two thirds of the students identified vocabulary such as ‘fear; ‘unconfident’ and ‘struggle’ to describe how they felt (Table 5.1).

8.3.2: Research Question 2: What past factors have affected students’ perceptions of learning mathematics?

Within the audit data, students were not specifically asked to comment on factors that may have affected their perceptions regarding learning mathematics; however, three themes were discussed by the students. Firstly, comments were related to their personal perceptions, whereby mathematics was identified as either a difficult subject that they might not be able to do, or something that they enjoyed and within their capabilities. The need for personal practice was also commented on within this area. Secondly, students identified particular areas of subject knowledge within mathematics which remained challenging, specifically referring to fractions and decimals and also algebra. The final theme to emerge from the audit was the perceived effect of the role of others, identifying the teacher, parents and peers in being possible influencing factors.

In comparing the potential influencing factors explored within the pre-teaching questionnaire, two similarities were identified. Firstly, Table 5.7 identified that the highest influencing factors were linked to the role of others to include the effect of the teacher and also other pupils, and that these influences were either seen in a positive or negative light. The qualitative comments delved deeper into this area and within the ‘role of others’ the effect of the teacher was identified as the highest rated influence. Comments relating to the teacher fell into two categories, and these were the characteristics of the teacher and matters relating to the teaching of mathematics (Table 5.9 and Chapter 5.3.1).

The second factor consistent with the audit was that of the personal perceptions of the students (Chapter 5.3.2). Students were not prompted to identify this area through any other aspect of the data collection process, but just as for the audit, their comments either related to mathematics being difficult and not something that they were able to do, or as being something that they enjoyed. As within the audit, reference was made to the need for practice within the subject.

Within the pre-teaching questionnaire the third influencing theme to be identified was that of setting arrangements (Chapter 5.3.3), and this was returned to within the focus group discussions (Chapter 7.4.4, Activity 4). References from both aspects of data related to this theme were in the main negative, with comments relating to the work being too hard and students feeling ‘out of their depth’, Students also felt limited by not being able to achieve highly within the set they were placed in.

In relation to research question two, the discussions suggest that there were a number of past factors affecting how the students felt about learning mathematics, and these were related to the role of the teacher, the role of others (including peers and parents), personal perceptions and setting arrangements.

8.3.3: Research Question 3: Is there a change in the students’ perceptions of learning mathematics after their first undergraduate mathematics education course?

The discussions related to Research Question 1 showed that prior to undertaking their first mathematics education unit the students were more negative rather than positive in their views of learning mathematics (Chapter 8.2.1). However, analysis of the post-teaching questionnaires identified that there had been a change in the students' views, and that the ratio had reversed from 2 to 1 negative to positive, to 1 to 2 (Tables 6.1 and 6.2). Alongside this, the number of students identifying themselves as having 'good' or 'very good' levels of understanding and confidence had increased by 27 and 23 percentage points respectively (Tables 5.4 and 6.4). Data to support these perceptions was also shown when more than 80% of students identified that they had higher comparative levels of confidence and understanding in mathematics at the end of the unit (Tables 6.6 and 6.7), similar to the same percentage of students who had made progress when their audit scores and end of unit scores were compared, also greater than 80% (61 out of 75 students, 81%, Appendix V).

The focus group discussions further support the identification of a change in perceptions, where the students utilised more positive vocabulary compared to negative vocabulary in similar proportions to the post-teaching questionnaire (Table 7.7). The analysis of comments demonstrated that although a number of students were cautious about the changes they perceived, all of the students felt more confident than before the mathematics unit, and showed greater interest and enjoyment in the subject than in the past (Chapter 7.4.1).

The discussions above demonstrate that, in relation to the research question three, there had been a change in perceptions after the students' first undergraduate course in mathematics education. Students felt more positive and confident than they had done previously and alongside this had gained a higher level of understanding in the subject.

8.3.4: Research Question 4: What strategies are identified that affect how a student feels about learning mathematics as an undergraduate?

There were consistencies between the post-teaching questionnaire and the focus group discussions in identifying a number of common factors which had affected how the students felt about learning mathematics as undergraduates. The data from both of these elements suggested that factors relating to the teacher and teaching had the highest positive influence on learning mathematics. This was evident in the post-teaching questionnaire within the closed question responses (Table 6.9) and also within the narrative discussions summarised in Table 6.10. Specific discussions relating to the teacher fell into two categories, the process of teaching mathematics and the characteristics of the teacher (Chapter 6.3.1). Similarly factors relating to the teacher and teaching were also identified as key influences and were discussed in three of the four group discussions (Tables 7.8 and 7.13). As within the post-teaching questionnaire, the nature of these discussions related to the process of teaching mathematics and characteristics of the teacher. Where students discussed the nature of teaching this included the need for clear demonstration and modelling, for methods to be broken down and for teaching sessions to have a suitable pace (Chapters 6.3.1, 7.4.2, 7.4.3 and Table 7.12). Elements relating to the characteristics of the teacher within the post-teaching questionnaire referred to 'not being made to feel silly' (Chapter 6.3.1), and were explored further by the focus group who identified the need for the teacher to have good subject knowledge, to have nurturing characteristics and to use clear language and explanation (Table 7.12).

The second theme to be identified through both the post-teaching questionnaire and the focus group discussions was related to students' personal perceptions regarding mathematics. It was the second most common theme to emerge from the post-teaching questionnaire narrative accounts (Table 6.10 and Chapter 6.3.2). Positive comments related to having enjoyed the mathematics unit and in being surprised at what they already knew; whereby others expressed concern that mathematics had never been a strength and felt limited by this. Similarly, within the focus groups reference was made to personal perceptions in three out of the four activities (Table 7.13), and the discussions reflected both the positive and negative aspects of these perceptions as identified within the post-teaching questionnaire. Where students felt limited by their own understanding in that they might just not be able to ‘do’ mathematics, others felt that they enjoyed the challenge and ‘the struggle’ behind learning (Chapter 7.4.1, activity 1). Where students felt positive about mathematics, words such as ‘enjoy’ and ‘excited’ were used and suggested that they felt empowered in learning the subject, whereas where they felt more negative, language such as ‘hate’ and ‘scared’ was used to describe their feelings (Chapter 7.4.4, Activity 4). However, where reference was made to the more negative feelings that the students had, these discussions were often related to past experiences, but tempered with reference to feeling more positive during the teaching sessions. One further aspect related to personal perceptions was where the students identified the need for personal practice in order to consolidate what was covered within teaching sessions, discussed by all of the focus groups (Chapter 7.4.4) and within the narrative discussions in the post-teaching questionnaire (Chapter 6.3.1).

The final key theme to emerge from the data was that of the role of others, in particular related to discussion with peers in teaching sessions. Within the post-teaching questionnaire the role of in-class discussion was identified as one of the top three positive influences (Table 6.9) within the closed questions, and also as the third rated influence within the narrative accounts (Table 6.10). Comments within this area of focus related to the nature of being able to reinforce personal understanding through verbalisation, and also of feeling supported by peers through the process (Chapter 6.3.3), similarly reflected within the focus group activities (Chapter 7.4.4); however, the focus groups were not all positive about working with others, which was rated more highly within Focus groups 1 and 3 than group 2 (Table 7.8); Some concerns were expressed that were not apparent within the post-teaching questionnaire, and related to students feeling concerned about not being able to contribute to discussion or feeling that there would be no one there to support them (Chapters 7.4.2 and 7.4.4).

The discussions above suggest that there were a number of factors affecting how the students felt about learning mathematics as undergraduates and that these related, in the main, to three key themes: the role of the teacher (split into personal characteristics and matters relating to the nature of teaching), personal perceptions and the role of others (specifically discussion and working with others).

8.4 Identification of Key Themes

The final research question was designed with the intention of being able to address the overall research aim. Having established that students had become more positive and confident in learning mathematics, the main purpose of the research was to identify any strategies that the students perceive might support them in learning mathematics. The focus here is to explore the recurrent themes that appear consistently throughout the research to aid the identification of any such strategies.

In order to create a template to support me in analysing the focus group discussions, Chapter 7 brought together the common themes identified through the literature review, audit and pre and post-teaching questionnaires (Table 7.4). An initial template was created and then adapted as the process of analysing the data took place (Table 7.6) which allowed for the acknowledgement of additional concepts as the data was reviewed (Gibson, 2010). In order to compare and contrast the themes identified from all aspects of the data collection process, the common themes from all of the aspects of data collected are summarised and analysed against the template strands in Table 8.1. Themes identified within all four aspects of the data are shaded in green and within three aspects of the data in yellow. Where there are common themes identified, these will be examined with the aim of identifying strategies to support adult in learning mathematics.

Comparison of data: Factors affecting how students (adults) feel about learning mathematics			
Audit	**Pre-teaching Questionnaire**	**Post-teaching questionnaire**	**Focus groups**
Teacher/teaching (TG/TR) - Lack of guidance from teacher (TR2)	Teaching (TG) - Pedagogy – explanation, pace (TG1) Teacher (TR) - Supportive – encouraging, enthusiastic, helpful, understanding, nurturing (TR1) - Unsupportive - lack of encouragement, lack of support (TR2) - Lack of subject knowledge (TR3/TG3)	Teaching (TG) - Pedagogy – modelling. Clear explanations, step by step breakdown of methods(TG1) - Pace of sessions (TG2) - Practice time in class (TG2) Teacher (TR) - Characteristics of the teacher (TR1)	Teaching (TG) - Pedagogy (TG1) - Subject knowledge (TG3) - Pace (TG2) Teacher (TR) - Personal characteristics (TR1) - Subject knowledge (TR2)
Role of others (R) - Made to feel a failure/scared (R3)		Role of others (R) - Discussion with peers (R1) - Support of others (R2) - Uncomfortable moving around at times (R3)	Role of others (R) - Discussion/group work (R1) - Nature of support (R2) - Influence on emotions (R3)
	Organisation of mathematics - Setting arrangements limiting development (S1) - Setting arrangements leading to an ability to achieve (S2)		Organisation of mathematics - Setting arrangements as a limitation (S1)
Personal perceptions (PP) - Scared of the subject (PP1) - Strong emotions surrounding mathematics (PP1/2) - Identified need to improve (PP3) - Difficult subject (PP3) - Confidence, or lack of (PP1/2)	Personal perceptions (PP) - Interest, enjoyment (PP2) - Difficult subject that cannot be done (PP3) - Need for personal practice (PP4) - Lack of confidence (PP1) - Embarrassment (PP1)	Personal perceptions (PP) - Enjoyment (PP1) - Challenging, but enjoyable (PP1) - Overwhelming (PP2) - Limited by own understanding (PP3)	Personal perceptions (PP) - Negative emotions (PP1) - Positive emotions (PP2) - Mindset (PP3) - Practice (PP4)
	Other - Attendance	Other Attendance	

Table 8.1: Template analysis of the data from the audit, pre and post teaching questionnaires and the focus group discussions

All four elements of the data collection process identified the teacher, the teaching and personal perceptions as factors that might affect the learning of mathematics. Three of the four elements of data collection also considered the role of others. It is these areas that will be considered further in light of the final research question and considered in light of the findings of others who have explored this area.

8.4.1 The Teacher and Teaching

In terms of considering the views of others who have explored adult learning in mathematics, there are those who suggest that the teacher is a key factor in supporting adults in overcoming negativity in this area (Tobias, 1993; Marikyan, 2009; Welder & Champion, 2011). Students within this research demonstrated similar perceptions in that in order for the teacher to support the learning of mathematics, they needed to have nurturing characteristics such as patience and being approachable and supportive (Chapters 6.3.1 and 7.4.3). Similarly, Dweck (2007) also endorses the need for a nurturing approach to support learning, particularly in an area which may be challenging. Where students had previously identified negative perceptions related to this theme, they suggested that they had felt unsupported by the teacher and were not encouraged to develop their skills within mathematics (Chapters 4.4 and 5.3.1).

The discussions relating to 'the teacher' also explored the tools that the teacher utilised in order to teach mathematics, and teaching was the only aspect of influence that was identified by all students as a positive influence within the post-teaching questionnaire (Table 6.9). The authors identified within the previous paragraph suggest that alongside the development of nurturing-type characteristics teachers should develop a range of strategies to support how the subject is taught. Similarly, in terms of the strategies that the students identified in supporting their learning of mathematics, they also identified the process of teaching as an influence that supported them in understanding mathematics. To be specific, they suggested that the teaching needed to incorporate clear modelling and explanation, where the teacher broke down different methods into appropriate steps, and linked this to the development of a clearer understanding of mathematics (Chapter 6.3.1, 7.4.2 and 7.4.3). Students also identified that making links from one aspect of mathematics to another also supported understanding (Chapter 7.4.3), similar to the role of ‘connectivism’ identified by Klinger (2011b).

Further to these teaching strategies, positive comments relating to the pace of the sessions were similar to those identified by Knowles (2005), who suggests that the atmosphere within a classroom for adult learners needs to be conducive to learning. The students suggested that this type of atmosphere included an appropriate pace and a relaxed atmosphere within teaching sessions (Chapters 6.3.2 and 7.4.3). It is to be noted here that there were two students who identified the pace of sessions as too slow for them, and that this was not conducive to learning (Chapter 6.3.2), supporting the view that the pace of teaching sessions needs to be appropriate to be needs of the learners. Additional teaching strategies identified by the students in supporting the learning of mathematics included the provision of time for practice and to ask questions within the teaching sessions. Consistent reference was also made to the provision of online materials to practice in between teaching sessions (Tables 6.9, 7,8 and Chapter 7.4.2).

In terms of further discussion regarding appropriate teaching strategies that might be considered, these related to working alongside others. As this was one of the three themes identified for discussion, further analysis of this theme will be discussed in the next section.

8.4.2: The Role of Others

Earlier consideration of the role of others in learning was considered in terms of the principles of constructivism, whereby the role of social interaction supports learning (Vygotsky, 1978; Wittgenstein, 1978). Others, more specifically, suggest that such an approach might support adults in overcoming negativity in learning mathematics (Gresham, 2007; Ashun & Reinink, 2009;) and that active learning may help adults to relate learning to previous experiences (Harper & Ross, 2011; Hegarty, 2011). Similarly, the role of others was identified on having an effect on learning, and although this initially seemed positive, there was some hesitancy expressed by some students.

Early discussions related to the role of others were linked to a lack of support from the teacher, or on being made to feel a failure by parents and peers (Chapter 4.4). This was not expanded upon within the pre-teaching questionnaire, but factors relating to the role of others were returned to in subsequent data collection elements. In terms of the positive aspects of working with others, these related to the views identified by the authors discussed above, with the students seeing discussion and working with others as a positive experience, particularly in being able to verbalise meanings, discuss answers and in seeing other students as a support network. Some saw the opportunity to explain something clarified their own understanding and gave them the confidence to move forward in their learning (Chapters 6.3.3, 7.4.2 and 7.4.4). However, this was treated with caution by others who felt uncomfortable in working with others and suggested that group dynamics could be a barrier to learning (Table 7.10 and Chapter 7.4.4).

8.4.3: Personal Perceptions

Dweck (2000, 2007) identifies self-perception as a potential barrier to learning and students' personal perceptions regarding learning mathematics were identified within all four aspects of data collection. Where they identified negative views about mathematics, these demonstrated similarities to the 'fixed mindset' identified by Dweck, in that they saw mathematics as a difficult subject that could not be done. This was the dominant view in both the audit (Chapter 4.4) and pre-teaching questionnaire (Chapter 5.3.2); however, also identified within these aspects of data was the consideration that for some students mathematics was something to be enjoyed.

Johnston-Wilder and Lee (2010b) suggest that it may be possible to change the way mathematics is perceived and in identifying the concept of 'mathematical resilience' believe that it is possible to support learners in changing their view of learning mathematics. Where students discussed a change in their perceptions regarding learning mathematics, this focussed on identifying feeling more confident and knowing more than they thought they did in the past (Chapter 6.3.2 and 7.4.1), with some students within the focus groups suggesting that they 'enjoyed the struggle!'. It is possible here to identify similarities with the development of 'mathematical resilience' and also in the development of the 'growth mindset' (Dweck, 2007), whereby the learners see challenge as a positive and something to be overcome. These students also identified the need for personal practice in order to continue to develop their understanding.

Both of the positive and negative personal perceptions surrounding the learning of mathematics is similar to the views of those who suggest that how a person feels about mathematics can affect their ability to understand it (Bekdemir, 2010; Buxton, 1981). Although the students overall demonstrated a more positive, rather than negative view regarding the learning of mathematics, this change in perceptions was not relevant to all students, and where this was the case was exemplified in comments within the post-teaching questionnaire (Chapter 6.3.2) and the focus group discussions (Chapter 7.4.1 and 7.4.4), whereby mathematics was still seen as a difficult subject. However, the proportion of students who made reference to their personal perceptions was halved during the course of the study, with just over half of the students commenting on this area in the pre-teaching questionnaire (Table 5.9) and just under a quarter in the post-teaching questionnaire (Table 6.10).

8.4.4 Summary of Key Themes

The purpose of this study was to identify the strategies to support adults in learning mathematics, and these may include factors associated with ‘the teacher and teaching’ and ‘the role of others’ and ‘personal perceptions’; however, addressing these factors may not bring about a change in perceptions for all students. Despite this, with the proportions of students having a more positive attitude towards mathematics, increased confidence and increased understanding overall, it could be considered that factors relating to the teaching of mathematics could contribute to supporting adults in learning mathematics.

These discussions now lead me to identify the strategies that might support students in learning mathematics, and the contribution this may make to the field of mathematics education.

8.5 Strategies to Support Adults in Learning Mathematics

Earlier discussions relating to negative perceptions surrounding mathematics identified those who suggest that this is an issue that needs addressing within student teachers and teachers (Haylock, 2010; Klinger, 2011a; Welder & Champion, 2011). Coben (2003, 2006) specifically identifies that although there has been much research related to the teaching of mathematics to children, there is less available to support the teaching of mathematics to adults. In light of this issue, this study has tracked a group of first year undergraduates through their first mathematics education unit in order to identify any strategies that they perceived supported them in learning mathematics. In analysing the data to this point, the previous section summarised three key themes that the students identified as affecting them in their learning. I now intend to examine these further in order to identify the strategies that may have supported them in learning mathematics.

Firstly, strategies related to the teaching of mathematics were rated as the highest positive influence and the only positive influence identified by all students (Table 6.9). The role of the teacher and teaching was also identified within all aspects of the qualitative data and the highest rated positive influence within the post-teaching questionnaire (Table 6.10) and alongside this the focus group discussions enabled a deeper exploration of the characteristics within this theme (Table 7.12). In utilising the qualitative data analysis from post-teaching questionnaires (Chapter 6.3.1), and the analysis of the focus group discussions (Chapter 7), the following teaching strategies have been identified in supporting adults in learning mathematics (Table 8.2).

Teaching Strategy 1 (TS1)	To have clear modelling and explanation of mathematical concepts (Chapters 6.3.1, 7.4.2 and 7.4.3)
Teaching Strategy 2 (TS2)	To break down each aspect of mathematics to demonstrate how each element is developed (Chapters 6.3.1, 7.4.1. 7.4.2 and 7.4.3)
Teaching Strategy 3 (TS3)	To make connections between different mathematical concepts (Chapter 6.4 and 7.4.3)
Teaching Strategy 4 (TS4)	To have a pace appropriate to the level of the students within teaching sessions (Chapters 6.3.1, 7.4.2 and 7.4.3)
Teaching Strategy 5 (TS5)	To allow time for discussion and questions (Chapters 6.3.3 and 7.4.3)
Teaching Strategy 6 (TS6)	To provide practice time within teaching sessions (Chapters 6.3.1 and 7.4.3)
Teaching Strategy 7 (TS7)	To provide online practice materials for practice outside of teaching sessions (Table 6.9 and Chapter 7.4.2)

Table 8.2: Suggested teaching strategies to support adults learning mathematics

It is also to be noted here that when discussing factors relating to the teaching of mathematics, students also gave consideration to the characteristics of the teacher, suggesting that there was a need for good subject knowledge in order to teach the subject. It was also suggested that the teacher should have nurturing characteristics, to include the need to be supportive, encouraging and patient, as well as being enthusiastic about mathematics (Chapters 6.3.1 and 7.4.3).

The role of discussion and working with others was, in the main, identified as a positive by twelve of the thirteen students who chose to comment in this area (Table

6.10). It is suggested that where there is provision for discussion, that this may support students in two ways: firstly in providing the opportunity to verbalise understanding of mathematical concepts and secondly as part of a support network amongst the group of students (Chapters 6.3.3 and 7.4.2). This triangulates with the need to allow time for discussion within the teaching sessions, but comes with a note of caution in that some students may feel uncomfortable in discussing with their peers and may only find it of value where they feel those they discuss with have similar values to themselves (Chapter 7.4.2).

The role of personal perceptions cannot be ignored, as it was identified as an influencing factor within all aspects of the data collection process. However, with the reduction in the number of students who identified negative personal perceptions surround the learning of mathematics (from 16 comments, Table 5.9 to 1 comment, Table 6.10), it may be possible to conclude that the teaching strategies employed may have contributed to this change in perception and potentially beginning to develop the notion of 'mathematical resilience' (Johnston-Wilder & Lee, 2010a). It is to be noted here that where students appeared to take responsibility for their own learning, they also identified the need for them to practice outside of teaching sessions (Chapter 4.4) and links to the need for the teacher to provide additional support materials (Table 7.8).

Finally, I earlier considered Knowles' (2005) six assumptions for adult learning (Table 2.1) and now return to these to demonstrate how the data collected from the students directly relates to a number of these themes addressed through the learning. Knowles suggests that there are aspects of teaching related specifically to working with adults, known as andragogy, and it is possible to see links not only to the teaching strategies identified in Table 8.2, but also to the additional factors the students identified that affect them in learning mathematics (Table 8.3).

Assumption	**Overview**	**Links to strategies and factors identified by students in affecting their learning of mathematics**
The need to know	Adults need to know why they need to learn something before undertaking learning	Teaching/teacher: ▪ Students valued clear explanation and a breakdown of mathematical concepts to support their understanding of why they were exploring specific areas of mathematics (TS1, TS2) Personal perceptions: ▪ Students identified reasons for studying mathematics for their own future (Chapter 4.4)
The learner's self-concept	Adults need to be responsible for making their own decisions	Personal perceptions: ▪ Students identified a need for personal practice outside of teaching sessions in order to support understanding (TS7) ▪ Students identified the need for attendance at teaching sessions (Table 5.9, Chapter 7.4.2)
The role of experience	Adults' prior experiences affect learning and these need to be recognised	Teaching/teacher: ▪ Students identified the need for teaching to build on understanding and to make connections to other aspects of learning (TS3) Role of others: ▪ Students identified the effect that others had on them in past learning and within teaching sessions (Chapters 4.4, 5.4, 6.33, 7.4.2 and 7.4.4).
Readiness to learn	Adults need to be ready to move from one stage of developmental learning to another	Teaching: ▪ Students identified the need for an appropriate pace in teaching sessions (TS4) ▪ Students identified the need to be able to ask questions and to be able to practice the concepts learnt (TS5, TS6)
Orientation to learning	Learning needs to be life centred in order to support adults in dealing with specific situations and task.	Teaching: ▪ Students identified the need for the teacher to respond to individual needs in order to support understanding (TS5)
Motivation	Adults may be motivated by external and internal forces	Teacher/teaching: ▪ Students recognised the need for the teacher to support and encourage them through nurturing characteristics (Chapters 6.3.1 and 7.4.3) ▪ Students recognised their internal forces to either motivate them to enjoy the challenge, or felt limited by such challenge (Chapters 4.4 and 7.4.1)

Table 8.3: Consideration of Knowles' six assumptions for learning alongside the research data

Consideration of Knowles' six assumptions for adult learning alongside the research data further support that the teaching strategies identified by the students support them in learning mathematics, but that these strategies need to be considered alongside the students' personal perceptions of mathematics and their own responsibilities within learning.

8.6 Evaluation of the study

Chapter 3 set out the proposed methodology for my research, and as advised by Creswell and Piano Clark (2011), my evaluation considers the match of the research design to the research focus and also the reliability, validity and generalisability of the study. Alongside this, McNiff and Whitehead (2006) identify that the researcher needs to adopt a reflexive approach in considering their own position within their research and to be accountable for their potential influence on others, and as such my role is also reviewed here.

Chapter 3.3 outlines the justification for my research focus, and my over-riding concern was that the research design should be informed by the research questions (Bryman, 2007; Collins & O'Cathain, 2009; Niglas, 2009). In taking a pragmatic approach to the research, I identified that a mixed methods study could be used to explore my research questions, whereby the use of qualitative methods could be used to explain the quantitative results of the study. Having clearly identified the research questions prior to designing the research process, I identified specific research methods to explore each question. Alongside this, every element of each data collection tool was aligned to a research question, with the aim of making every element of the data collection process focussed on what I was trying to find out (Chapter 3.4).

Taking the time at the start of the study to design the research methods appropriate to the research questions was supportive when analysing each individual aspect of the data (Chapters 4, 5, 6 and 7), as I was regularly able to return to the identified research questions and draw out the key findings as the research progressed. This in turn supported the process of triangulation in enabling me to draw conclusions from the study (Chapter 8.2). Where there were quantitative aspects of the data collection methods a number of themes were identified, and these were further explored through the qualitative elements of the study, providing a greater understanding of the issues examined. Hence I believe that a mixed methods research design was appropriate to the study in that using a range of approaches allowed me to explore my findings in depth.

Further consideration of the methods utilised leads me to consider the potential issues surrounding reliability, validity and generalisability, which were identified as potential threats to the study in Chapter 3.5. In terms of validity, I carried out the approach to this as planned, in aligning my methods closely to the research questions and using literature from the field as a starting point to support the construction of my data collection tools. As planned, I utilised support from colleagues in the field to review content and all methods were piloted with students from the previous intake year to that of the study, so that changes were made to ensure clarity in terms of questions within the questionnaires and the focus group discussions. One concern that may have affected the validity of the study was the response rate of participants involved within the research. Robson (2011) suggests that poor response rates could mean that the sample involved in a study may not be representative of the whole sample; however, within this study, response rates were high for the audits and pre and post teaching questionnaires, and for this I am thankful to the participants. All 75 students took part in the initial audit, 68/75 students in the pre-teaching questionnaire and 64/74 in the post-teaching

questionnaire. In terms of the focus group discussions, my concern was that I would not gain a representative sample of students for whom there had been a change in their perceptions of mathematics during the course. However, Chapter 7.2 outlines the process for this and demonstrates that the sample group had increased in confidence and attainment and hence were an appropriate sample for the study.
In terms of reliability, I planned to make the data collection methods as trustworthy as possible by making my questions clear and unambiguous. In order to do this, all questions asked were linked to the research questions within the study. I was aware that some of the terms used within the questionnaire were subject to personal interpretation, such as levels of confidence and understanding, and in social research it is not possible to eliminate such interpretations. However, in order to allow for comparison of perceptions over time, there was a consistency in the terms used throughout the different data collection methods. Alongside this, all research questions were addressed within more than one aspect of the data collection process, to allow for triangulation of results within the analysis phase (Table 3.3).

With regards to my dual role as practitioner-researcher, I could not discount my own role as the students' teacher, and this role was disclosed to the students at the start of the research process. I made it clear to the students that my priority was to them and not to my research, and as such all questionnaires were anonymised and could not be linked back to any individual student. Any assessments taken throughout the unit were marked anonymously, so should a student have been concerned about their responses it would not have been possible to use any information related to this to influence grading. Although the students who took part in the focus groups could be identified by me as the researcher, these discussions took place after all assessment work had been marked and hence there could be no influence on this.

With both quantitative and qualitative data utilised within the study, I was aware of the need to be able to interpret each appropriately, and that there was the potential that my interpretation of the data might be biased. I therefore planned my approach to analysis prior to embarking on the study (Chapter 3.6). With regard to the quantitative data, I was aware that I needed to move beyond the presentation of the data to move on to explain my findings (Newby, 2010), and this process was followed when analysing all aspects of the quantitative data. Miles and Huberman (1994) suggest that issues related to the interpretation of qualitative data may be influenced by research bias, and that explicit, systematic methods are needed to analyse such data. As such, thematic coding methods were identified for each aspect of qualitative data collection and were reviewed by colleagues in the field to help identify any themes that may have been omitted. The coding systems I used were supportive in enabling me to identify key themes throughout the research, and to manage the large volume of data I had collected (which was far greater than I had anticipated!).

I believe that in taking the above steps I have done my best to minimise the influence that I may have had on the study, but that it would not be possible to completely eliminate both the personal interpretations of the students and of myself, and therefore cannot discount that there is likely to be some influence by me as a practitioner-researcher on the study.

Finally, in considering generalisability, I was aware that the individual nature of any one setting may have implications in terms of being able to generalise in reference to other settings (Gorard, 2002; Hillage, Pearson, Anderson, & Tamkin, 1998); However, as suggested by Bassey (2001), I consistently linked my themes to other studies that had explored issues related to adults learning mathematics, and a summary of this can be found in Table 7.4. With a number of consistent themes being identified throughout my reading and within the data analysis, it might be considered that there is the potential for the findings from this study to be transferred to the wider body of knowledge within this field (Denscombe, 2010).

8.7 Contribution to the Field

My reasons for carrying out this research stemmed from wanting to 'make a difference' to the students who I worked with in supporting them in learning mathematics. Concerns regarding the negative perceptions in relation to mathematics in the UK (DCSF, 2008; Wolfe, 2014), and the identification of a lack of research to support the teaching of mathematics to adults (Coben 2003, 2006) were considered when exploring how my research would contribute to the field of mathematics education. I therefore planned to identify strategies that might support adults in learning mathematics and support 'a change in attitude' as identified by the National Numeracy Team (2014)

In analysing the combined aspects of data, there were a number of consistent factors that appeared to affect how students felt about learning mathematics, relating to the role of the teacher, their personal perceptions regarding mathematics and the role of discussion and working with others. However, throughout the research, the one theme that was consistently identified as having the most influence was that of the teacher and the teaching strategies used. In terms of unpicking what this might mean as regards to the factors that were a positive influence, these were considered alongside Knowles' six assumptions related to adult learning (2005). As a result of this, seven teaching strategies were identified that might be considered to support adults learning mathematics within the field of mathematics education:

- To clearly explain and model mathematical concepts
- To break down each aspect of mathematics and explain how each element is developed
- To make connections between different mathematical concepts
- To ensure that the pace of the teaching is appropriate to the needs of the learners
- To allow time for questioning and discussion within teaching sessions
- To provide time for practice within teaching sessions
- To provide online practice materials for practice outside of teaching sessions

A point to note here is that within my earlier discussions related to the literature review, it was evident that there were a number of positive views relating to the use of constructivist approach to learning mathematics (Ashun & Reinink, 2009; Gresham, 2007; Johnston-Wilder & Lee, 2010a; Wittgenstein, 1978) and others who advocated a more connectionist approach (Skemp, 1971; Askew et al, 1997; Klinger, 2011;). However, these findings appear to demonstrate that the students within this study considered that a combination of these two approaches supported them in learning mathematics and that these two approaches may be used in partnership. I also identified that the teaching strategies may need to be considered alongside the characteristics of the teacher, as the students suggested that the teacher needed to be patient, encouraging and supportive.

Alongside these teaching strategies it has also been acknowledged that consideration also needs to be given to the students' personal perceptions related to learning mathematics; however, in light of the change in these personal perceptions, whereby the students became more positive in learning mathematics, these teaching strategies may be considered as having the potential to support a more positive attitude towards learning mathematics and hence an increase in understanding (Evans, 2002; Ashcraft and Krause, 2007).

This research stemmed from my own background and experience in teaching mathematics to both adults and children, and I now return to consider the implications of this research on my own practice.

8.8 Implications for practice and next steps

In outlining my research focus (Chapter 1), I identified my past experiences in working with both adults and children in learning mathematics. In particular, I had identified a trend whereby students who attended the BA Applied Education Studies course demonstrated negative perceptions relating to the mathematics units on the course before they had even begun to study them! Ultimately I wanted to be able to support the adults I worked with to the best of my ability.

Having examined the full range of data collected for this project I have identified that there are a number of strategies that might be considered as supporting adults in learning mathematics. Specifically, seven teaching strategies are identified that support the andragogical perspective, the teaching of adults, and are drawn from the triangulation of all elements of the data collection process (Table 8.2). Other factors identified that may affect students learning of mathematics include the effect of their personal perceptions on learning mathematics and the role that others may have in their learning. The study itself has been evaluated in terms of reliability, validity and generalisability, and it is suggested that the study has been as reliable and valid as possible, bearing in mind the limitations of the interpretation of individuals within the research and the role of myself as practitioner-researcher. It is also suggested that by comparing the results of this study with others, that the findings may be generalisable to other settings. I shall now consider the practical implications of this research in light of my own current practice and draw the project to a close.

In terms of the implications of this research on my own practice, I am now mindful of the specific strategies that students have found supportive and will endeavour to plan and utilise these strategies within my teaching. I am also aware, in particular, that although the role of discussion and working with others has been identified as a potentially positive influencing factor, this was not the case for all students, and in some cases limited and restricted involvement. It is the management of discussion and group work that therefore needs to be considered in more depth. Finally, with the role of personal perceptions being a consistent factor throughout the research, I cannot discount the personal ‘mindset’ of the adults I work with (Dweck, 2007). However, with the reduction of negative perceptions regarding learning mathematics following the completion of the first mathematics unit, there is the potential to consider that the teaching strategies identified may be support the development of ‘mathematical resilience’ (Johnston-Wilder & Lee, 2010b).

On commencement of this research project, the BA Applied Education Studies part-time course was taught on one campus and at the time I was the only mathematics specialist teaching on the course. In September 2012, the course expanded to three campuses and a fourth one in 2013. My personal role has also expanded from Senior Lecturer to Course Coordinator in that time, which allows for a wider overview of the course as a whole and also offers the opportunity to work with others in teaching mathematics. The staffing for the course has increased, with one other mathematics specialist joining the course and others identified to work within the team. Therefore the next steps in terms of utilising this research also involve a dissemination of findings to the team involved in teaching the mathematics education units and a structured approach to exploring the impact of the teaching strategies identified. With this in mind, the recommendations based on the findings of this project are as follows:

- To disseminate the seven identified teaching strategies to the wider mathematics team and explore the impact of these strategies on the students attending the BA Applied Education Studies course.
- To consider how the personal approach of tutors might affect the students disposition towards learning mathematics
- To carry out further research on the effect of discussion and working with others on adults learning mathematics
- To consider further the implications of students' personal perceptions regarding learning mathematics and the development of 'mathematical resilience' might be further supported.

8.9 Final Comments

I began this process expecting the nature of a long term extended piece of research to be a challenge and there were times where I could easily have given up. However, one aspect of the research that I had not considered at the start was the alignment of me as both a student and teacher, which the students who were part of the study appeared to value. Without the students contributions this study would not have been possible, and it is them I thank in regards to their involvement in not only the data collection processes, but their continued encouragement to persist with the research. I also thank those students who took part in the pilot study, as this enabled me to develop the data collection tools in order to provide as much clarity and focus as possible. I hope that I have done the students justice in completing my research and that the strategies identified will support subsequent students in learning mathematics.

Appendices

APPENDIX A: BA (Hons) Applied Education Studies Units

Year 1 (Level 4)

Unit Title	Credits
Skills for Teaching	30
English Language for Teachers	15
Basic Science for Teachers	15
Introduction to Mathematics Education	15
Managing the Learning Environment	15
Developing Teaching	30

Year 2 (Level 5)

Unit Title	Credits
Mathematics and Teaching	15
The Wider Curriculum and Research in Schools	30
Personalised Learning	30
Literacy for Teachers	15
Scientific Methods for Teachers	15
Reflecting on Practice	15

Year 3 (Level 6)

Unit Title	Credits
Developing a Research Proposal	15
English Literature for Teachers	15
Approaches to Learning	15
Professional Practice in Schools	30
Teaching Mathematical Problem Solving	15
Research Project	30

APPENDIX B: Questions for the initial audit of mathematical skills

Number

Q1. Write the number 2 245 789 in words.

Q2. Calculate the following, **withou**t using a calculator:

a. 375 + 192

b. 375 – 196

c. 378 x 23

d. 378 ÷ 5

Q3. Elaine has £672 in her bank account. The direct debit for her mortgage, of £490, goes out and she buys a coat for £98, a pair of boots for £86 and a matching handbag for £45 using her debit card. What is her new balance?

Q4. Write:

a. ¾ as a decimal

b. 36% as a fraction

c. 0.8 as a fraction

Q5. What is 30% of £400?

Q6. Calculate:

a. $^{2}/_{3} + ^{5}/_{6}$

b. $^{3}/_{4} \times ^{3}/_{10}$

Algebra

Q7. If x = 7, find the values of:

a. 5x + 9

b. 7(x – 5)

c. (x – 5)(x + 6)

Q8. Simplify these expressions by collecting like terms:

a. x + 2y + z + 3y + 8z

b. 8x – 3y – 4x + 5y – 3z

c. 4b – 9c + 2c – 3c

Q9. Solve these equations:

a. 5b = 35

b. 4b + 3 = 15

c. 3(y – 4) = 15

Shape, space and measures

Q10. What is …

a. 3.4 m in cm?

b. 2500 g in kg?

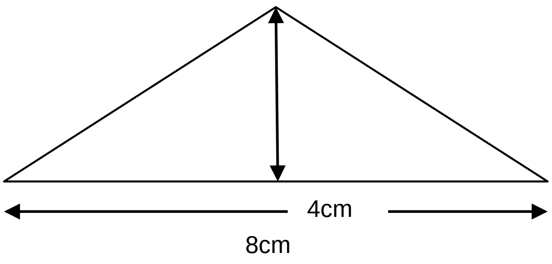
c. 2.56 kg in g

d. 1.4 l (litres) in ml?

Q11. What is the of a rectangle 24cm by 10cm?

Q.12. What is the area of a rectangle 13cm by 10cm?

Q.13. What is the area of this triangle?



Q14. Calculate the volume of a cuboid whose length is 9cm, breadth 4cm and depth 11cm.

Q15. Draw the lines of reflective symmetry on this shape.

Data handling

Q16. This is a set of test results:

13, 24, 49, 25, 49, 38, 36, 41, 49, 38

Find:

a. The mean

b. The mode

c. The median

d. The range

Q17. There are 20 children in class 1 and they carry out a pet survey in their class. Complete the frequency table for the data collected:

Animal	Tally	Frequency
Dogs	I I I I	
Cats	~~IIII~~	
Fish	I I	
Rabbits	~~IIII~~ I	
Hamsters	I I	
Guinea pigs	I	

Draw a bar chart for this data (on squared paper)

Q18. The pupils also want to draw a pie chart for the data. Calculate the angle needed for the **cat** section of the pie.

Q19. On a standard 1-6 die, identify the probability of throwing:

a. 6

b. 7

c. If the 1 is replaced by another 6, what is the probability of throwing a 6?

APPENDIX C: **Perceptions of Learning Mathematics: Student Questionnaire 1**

These questions relate to how you feel about mathematics today.

Q.1. Think about the times when you have been learning mathematics. Circle all of the words which you associate with this. You can circle as many or as few as you wish.

strong weak fear

interest easy confident unconfident

struggle enjoy difficult

Q2. How well do you think you understand mathematics – please rate on a scale of 1 to 5.

1	2	3	4	5
I do not understand mathematics.	I have a low level of understanding in mathematics	I have a reasonable level of understanding in mathematics	I have a good level of understanding in mathematics	I have a very good level understanding of mathematics

Q3. If confidence is identified as a belief in your abilities, how confident do you feel about learning mathematics?

1	2	3	4	5
I do not feel confident about learning mathematics.	I have a low level of confidence in learning mathematics	I have a reasonable level of confidence in learning mathematics.	I feel confident about learning mathematics	I feel very confident about learning mathematics. .

Q4. In the past, what type of learning environment in mathematics have you been used to? Tick as many responses as you wish to.

	Yes	No	Sometimes
Allowed to ask questions			
Encouraged to discuss answers			
Allowed to work with a partner or in groups			
Worked in silence			
Encouraged to keep trying until you understood			
Worked completely alone			
Other (please specify):			

Q5. Think about the factors that may have affected how you feel about learning mathematics (positive or negative). Please tick any that you think may apply to you.

	Positive influence	Negative influence
Attendance at school		
Personal behaviour at school		
Effect of the teacher		
Effect of other pupils		
Personal issues outside of school		
Tests and exams		
Other (please specify):		

Q6. Think about your perceptions of learning mathematics. Identify an experience that you think may have affected how you feel about the subject today. Please give as full a description of this experience and how you think it has affected your current feelings about learning mathematics.

Thank you for taking the time to complete this questionnaire.

APPENDIX D: Perceptions of Learning Mathematics: Student Questionnaire 2

These questions relate to how you feel about mathematics today.

Q.1. Think about the times when you have been learning mathematics. Circle all of the words which you associate with this. You can circle as many or as few as you wish.

strong weak fear

interest easy confident unconfident

struggle enjoy difficult

Q2. How well do you think you understand mathematics – please rate on a scale of 1 to 5.

1	2	3	4	5
I do not understand mathematics.	I have a low level of understanding in mathematics	I have a reasonable level of understanding in mathematics	I have a good level of understanding in mathematics	I have a very good level understanding of mathematics

Q3. If confidence is identified as a belief in your abilities, how confident do you feel about learning mathematics?

1	2	3	4	5
I do not feel confident about learning mathematics.	I have a low level of confidence in learning mathematics	I have a reasonable level of confidence in learning mathematics	I feel confident about learning mathematics	I feel very confident about learning mathematics. .

These questions relate to how you feel about mathematics since completing your first mathematics course as undergraduates.

Q4. How do you rate your level of understanding of mathematics now compared to before you started the course?

1	**2**	**3**	**4**	**5**
I have a much lower level of understanding in mathematics	I have a lower level of understanding in mathematics	I have the same level of understanding in mathematics	I have a higher level of understanding in mathematics	I have a much higher level of understanding in mathematics

Q5. How do you rate your level of confidence in learning mathematics now compared to before you started the course?

1	**2**	**3**	**4**	**5**
I have a much lower level of confidence in learning mathematics	I have a lower level of confidence in learning mathematics	I have the same level of confidence in learning mathematics	I am more confident in learning mathematics	I am much more confident in learning mathematics

Q6. Think about the factors that may have affected how you feel about learning mathematics during the course. Please rate how you feel the following may have influenced you throughout the course, placing a tick in the appropriate box for each choice (from 1 being a negative influence to 5 being a positive influence)

	1 Strong negative influence	2 Negative influence	3 No influence	4 Positive influence	5 Strong positive influence
Attendance at sessions					
Teaching					
Other students					
Tests and exams					
Online materials					
Discussion boards &blogs					
Websites					
Outside influences					
Drop in sessions					
In class discussion					
Other (please state):					

Q7. Think about your perceptions of learning mathematics over the first course you have completed as undergraduates. Identify an experience, or experiences, that you think may have affected how you feel about it today? Please give as full an answer as possible.

Thank you for taking the time to complete this questionnaire.

Appendix E: Items from the unit test taken in March 2012

Mental Calculation

1. 5.2 + 3.8
2. 9 – 2.5
3. 527 ÷ 100
4. 2.6 x 10
5. √81
6. Write 0.3 as a fraction
7. Write 0.75 as a percentage
8. Calculate 20% of 200
9. Calculate the area of a rectangle twenty centimetres by fifteen centimetres
10. Write 94cm in metres
11. Write 205g in kg
12. Write 1.25 kg in g
13. Write 0.75 litres in ml
14. 8 squared
15. ¾ of 80

Non-calculator questions

1. (a) Work out 394 × 62
   (b) Calculate 16.3 + 17.9
   (c) 0.4 × 0.2
   (d) (i) Write 34.2477 to 1 decimal place.
   (ii) Write 34.2477 to 3 decimal places.

2. (a) Kim buys 71 stamps which cost 19 pence each.
   By using suitable approximations, estimate the total cost of the stamps.
   (b) There are 96 stamps on a sheet. How many sheets of stamps will Kim need to buy to ensure that she can send 300 letters? Show your working.

3. Write the following as fractions in their simplest forms:
   (a) 0.6
   (b) 0.29
   (c) 65%

4. What is the number 7 673 099 in words?

5. The price of a computer is £840.
   In a sale the price is reduced by 25%.
   What is the sale price?

6. Beth has 400 roses.
   48 are yellow.
   What percentage of the roses is yellow?

7. Here is a number sequence.

   1 4 7 10 13

   (a) Write down the next two numbers in the sequence.

(b) Describe a rule for continuing the sequence.

8. A bag contains 12 blue and 8 green counters.
A counter is chosen at random.
(a) Find the probability that the counter chosen is red.
(b) Find the probability that the counter chosen is green.
Give your answer as a fraction in its lowest terms.
(c) 10 yellow counters are added to the bag.
Calculate the probability that a counter chosen at random is green or yellow.

Sample questions where a calculator is available

1. a). Convert $^{11}/_{17}$ to a decimal. Give your answer correct to three decimal places.
b). Put the following numbers in order of size from the smallest to the largest:

$^{11}/_{17}$, 65%, $^{3}/_{5}$, 0.63

2. Mrs Brown's bill for servicing her car is £96 plus VAT.
VAT is charged at 17.5%.
What is her total bill?

3. Write your answers for these questions as fractions in their simplest forms:

(a).Lucy makes some curtains for her living room and her bedroom.
In the living room she uses $3\frac{2}{3}$ metres of material.
In the bedroom she uses $2\frac{4}{5}$ metres of material.
How many metres of material does she use altogether?

(b) Work out**:** $4\ ^{3}/_{4} - 1\ ^{2}/_{5}$

(c) $\frac{2}{5} \times \frac{1}{4}$

4**.** Abby sees the same model of digital camera for sale in two different shops.

A camera from 'Digicam' is 15% off the original price of £288
A camera from 'Pictures4u' is 1/6 of the original price of £288

Calculate the final cost of the camera from
(a) Digicam,
(b) Pictures4u.

5. (a) Simplify $5p + 2q – q + 2p$
(b) Simplify $3d – 5e + 4d + e$

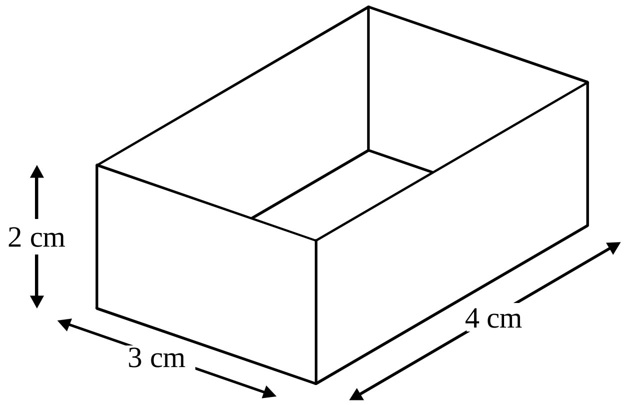
6. Solve the following equations:
a). 6y = 30
b). 7c + 10 = 45

c). 3d – 3 = 15

d) $^{24}/b = 8$

7. Brian travels 150 miles in 3 hours.
Clive travels 110 miles in 2 hours.
Who is travelling faster?

This box has the shape of a cuboid. It has no lid.



(a) Find the volume of the box.

(b) What is the external surface area of this cuboid?

11. The time, in minutes, that seven teenagers spent using their computer and spent watching TV on one day is recorded in the table.

Time spent using computer (minutes)	10	20	30	40	45	55	60
Time spent watching TV (minutes)	50	40	45	40	30	30	20

(a) Plot these data as a scatter graph

(b) Draw a line of best fit on your scatter graph.

(c) Describe the relationship shown in the scatter graph.

12. The head teacher of a secondary school thinks that pupils who come to school by bus are more likely to be late than those who do no not travel by bus. In order to test this theory, the head teacher carries out a survey on 100 pupils in Years 7 and 8, for 5 consecutive Tuesdays.

These are the results:

Method of travel	Number of student days	Number of lates
Bus	150	40
Bicycle	50	10
Car	100	22
Walk	200	25
TOTALS	**500**	**97**

a. Do the results suggest that the head teacher is correct? **(3 marks)**

APPENDIX F: Focus Group Discussion: Activities and discussion points

Introduction

Explain that the purpose of the focus group is to gain an understanding of how the students feel about learning mathematics as adults, alongside factors they believe support or hinder them.

Activity 1: To gain an overview of how the students feel about mathematics

Show the students the ten words (on laminated cards) from the questionnaire where they were asked to circle how they feel about mathematics today:

Strong, weak, fear, interest, easy, confident, unconfident, struggle, enjoy, difficult

Ask the students to discuss amongst themselves how they feel about mathematics now.

Activity 2: To explore the factors identified from question 6 on influences in learning mathematics as adults (the themes in this question were originally identified through literature)

Explain that in the questionnaire they completed, they were asked to identify factors that had influenced how they felt about learning mathematics during their first course as undergraduates and that it is this that will be explored further.

Ask the students to place the following cards in order of most positive to least positive influence in learning mathematics as adults, discussing with each other as they go:

Attendance at sessions, teaching, other students, tests and exams, online materials, discussion boards and blogs, websites, outside influences, drop in sessions, in class discussion

Activity 3: To explore the students' perceptions of teaching as a factor in influencing how people feel about learning mathematics.

Lead on from Activity 2 explaining that 'Teaching' was the only factor chosen by every student as affecting how they felt about learning mathematics.

Move this question on to explain that 'The Teacher' and 'Teaching' were also the top factors when exploring the students' comments further.

Have a piece of flip chart paper with 'The Teacher' at the top of one and 'Teaching' at the top of the other.

Ask the students to identify what characteristics they would put under each (both positive and negative) that affect how they feel about learning mathematics.

Activity 4: To explore the other factors identified in students' comments

Explain that the other top factors identified as factors affecting how they feel about mathematics were 'Discussion' and 'Personal understanding'. Taking discussion first:

Ask the students to discuss what effect discussion and working with others had on their learning of mathematics.

Follow up with asking the students if they had such opportunities in the past.

Finally, ask the students how their personal view has affected their learning of mathematics (prompts: previous understanding, personal limitations, practice ...)

APPENDIX G: ETHICAL APPROVAL FORM

Application for Ethical Approval for Research Degrees
(MA by research, MPHIL/PhD, EdD)

Name of student	MA By research	EdD	PhD
Karen Wicks		X	

PLEASE NOTE THAT IN ORDER TO PROVIDE ANONYMITY AND CONFIDENTIALITY ALL SIGNATURES AND IDENTIFYING NAMES HAVE BEEN REMOVED FROM THIS DOCUMENT. THE SIGNED DOCUMENT CAN BE VIEWED ON REQUEST AND WILL BE MADE AVAILABLE TO THE EXAMINERS

Project title: An exploration into the perceptions of undergraduates' views on strategies to support them in overcoming a fear of mathematics

Supervisor: [redacted]

Funding Body (if relevant): [redacted]

Please ensure you have read the Guidance for the Ethical Conduct of Research available in the handbook.

Methodology
Please outline the methodology e.g. observation, individual interviews, focus groups, group testing etc.

- Audit of attainment and confidence
- Questionnaires
- Interviews/focus groups

Participants
Please specify all participants in the research including ages of children and young people where appropriate. Also specify if any participants are vulnerable e.g. children; as a result of learning disability.

- First year undergraduate students, all of adult age.

Respect for participants' rights and dignity
How will the fundamental rights and dignity of participants be respected, e.g. confidentiality, respect of cultural and religious values?

- Participants will be fully informed of the research project and will have the right of voluntary informed consent (BERA 2004). This will be done by ensuring that the focus for the research is explained clearly and that participation at any point is optional. Where the data collected is for part of the participants' degree course (audit of attainment and confidence), the use of such data will be requested and participants will have the right to withdraw their data from the study by an agreed date. Participants will be assured that whether or

not they choose to participate, their course grades will not be affected.
- All data collected will be anonymised so that no individual may be identified.
- Cultural and religious values will be respected throughout.

<u>Privacy and confidentiality</u>
How will confidentiality be assured? Please address all aspects of research including protection of data records, thesis, reports/papers that might arise from the study.

- Initial audits and confidence levels will be recorded on University systems, which are password protected. From this records will be anonymised, so that no students can be identified and data will be uploaded to SPSS. Files will be stored electronically, again password protected.
- Questionnaires will be completed anonymously, so all record will be anonymous. Data will be uploaded and stored electronically in password protected files.
- Interviews will be recorded digitally and password protected. Names will be changed to allow for anonymity.

All records will remain confidential. Students will be informed that data may be shared with supervisors and appropriate colleagues, but to maintain confidentiality and anonymity, no individual will be named personally. Students will also be made aware that these anonymised records will be used within the writing of the thesis, and may contribute to papers and reports. Students will be made aware of this possibility at the outset and given the opportunity of voluntary informed consent for involvement.

<u>Consent</u> -
Will prior informed consent be obtained?
From participants? Yes **From others?** Yes
Explain how this will be obtained. If prior informed consent is not to be obtained, give reason:
Participants will be informed of the nature of the study and asked for their consent. It will be made clear to those involved that non-participation will have no effect on their studies. All aspects of the ‘respect for participants’ rights’ will be adhered to. Contact details of the researcher will be made available to all participants should they require additional information.
Line manager has been consulted for consent for research within the workplace and approval has been given.

Will participants be explicitly informed of the student’s status?
Yes. Participants are already aware of the student’s status as a lecturer and will be informed about the status for EdD research.

<u>Competence</u>
How will you ensure that all methods used are undertaken with the necessary competence?
- Methods to be used will be discussed and agreed with supervisors for identification of any issues that might be of concern.
- Methods will be piloted during Phase 1 of the EdD.

- Reference will be made to literature on research methods to support in the identification of appropriate methods.
- Sufficient time will be given for data collection to avoid unnecessary stress to participants.

Protection of participants
How will participants' safety and well-being be safeguarded?

- Participants will be informed of the nature of the research and given the opportunity for informed voluntary consent. Any participant not wishing to take part in the research will not be coerced into doing so.
- Should any participant become distressed during the data collection process, the process will cease and the participant's welfare prioritised.
- Participants will be made aware that there will be no impact on their undergraduate grades.

Child protection
Will a CRB check be needed? No (If yes, please attach a copy.)

Addressing dilemmas
Even well planned research can produce ethical dilemmas. How will you address any ethical dilemmas that may arise in your research?

- Ethical dilemmas will not be ignored and will be fully discussed with supervisors to discuss the best course of action.

Misuse of research
How will you seek to ensure that the research and the evidence resulting from it are not misused?

- Clear parameters will be set for the use of the research at the outcome and adhered to.
- Data will not be made available to others for research beyond the original purpose.

Support for research participants
What action is proposed if sensitive issues are raised or a participant becomes upset?

- Should any participant become distressed during the data collection process, the process will cease and the participant's welfare prioritised.
- Should the participant become upset because they are discussing sensitive issues, they will be given the choice as to whether or not to continue to process.

Integrity
How will you ensure that your research and its reporting are honest, fair and respectful to others?

- Clear research objectives will be defined and the research processes decided upon to inform those objectives.
- Data will be triangulated to allow for data to be compared and contrasted against the specified objectives.

- Every effort will be made to ensure that the data presented is true and accurate.

What agreement has been made for the attribution of authorship by yourself and your supervisor(s) of any reports or publications?

Publications relating to the work of the doctorate will include supervisors' names.

APPENDIX H: Letter to students at the start of the research

Dear Student,

A few months ago you may remember completing mathematics audits and you also had the opportunity to rate your confidence and provide me with some background information. At the time, I explained that I am currently undertaking research for my Doctorate in Education on students' perceptions of learning mathematics.

I now wish to explore, in more depth, students' perceptions of learning mathematics as they embark on their degree course. In order to support this process, I would be grateful if you could take the time to complete this questionnaire. You will not be asked to identify yourself, so therefore all responses will remain anonymous.

Participation is entirely voluntary and your studies will not be affected.

If you have any questions about the research, or wish to be involved further, please contact me by e-mail at [redacted]

Thank you for taking the time to complete the questionnaire.

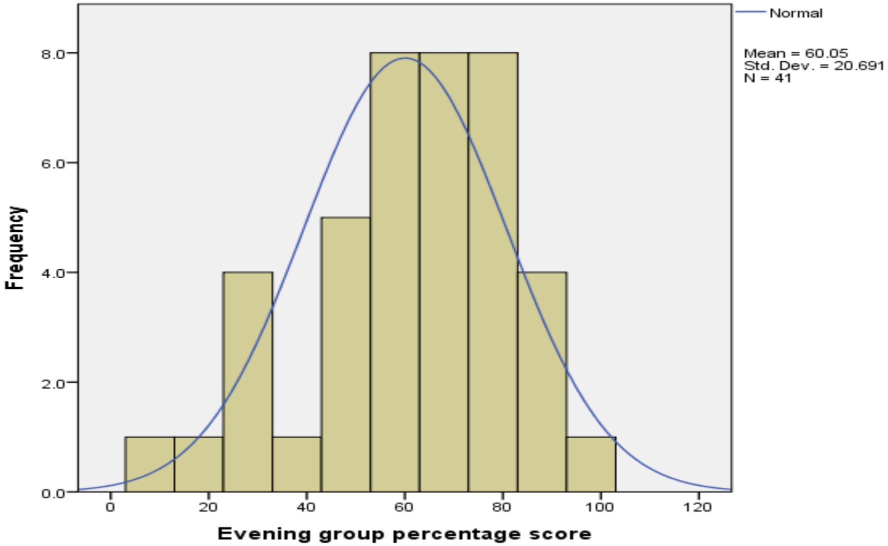
Karen Wicks

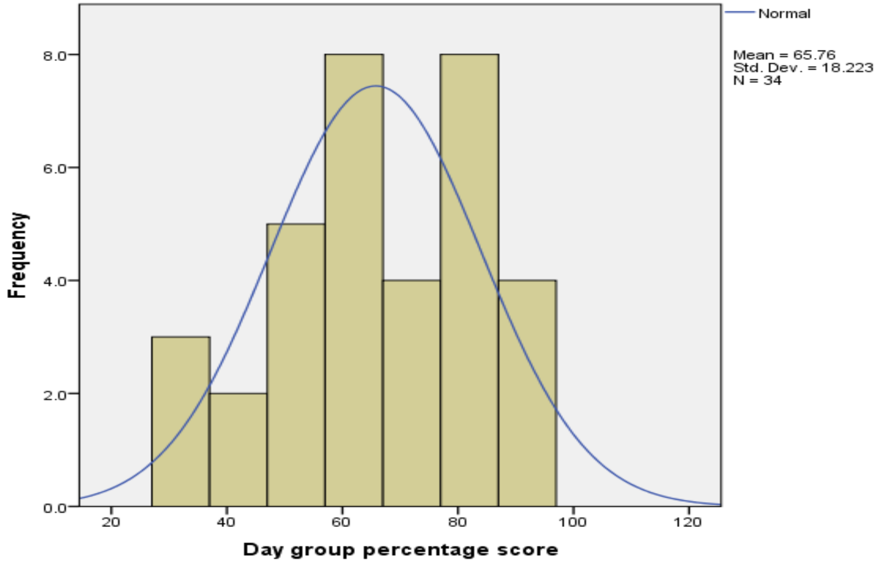
Senior Lecturer, BA Applied Education Studies

APPENDIX J: Ethnicity Crosstabulation

Ethnicity * Day or eve Crosstabulation					
			Day or eve		Total
			Day	Evening	
Ethnicity	White British	Count	26	32	58
		% within Day or eve	81.2%	78.0%	79.5%
	Mixed Heritage	Count	2	0	2
		% within Day or eve	6.2%	0.0%	2.7%
	Black Caribbean	Count	0	1	1
		% within Day or eve	0.0%	2.4%	1.4%
	Pakistani	Count	1	3	4
		% within Day or eve	3.1%	7.3%	5.5%
	Indian	Count	0	2	2
		% within Day or eve	0.0%	4.9%	2.7%
	Bangladeshi	Count	3	3	6
		% within Day or eve	9.4%	7.3%	8.2%
Total		Count	32	41	73
		% within Day or eve	100.0%	100.0%	100.0%

APPENDIX K: Audit percentage scores for the day and evening groups





Tests of Normality

	Day or Eve	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Percentage score	Day group	.106	34	.200*	.960	34	.240
	Evening group	.092	41	.200*	.972	41	.413

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

APPENDIX L: Spearman's rho correlations for individual day and evening groups in relation to perceived understanding and perceived confidence, pre-teaching questionnaire

Correlation of perceived understanding and confidence for the day group				
			Understanding	Confidence
Spearman's rho	Understanding	Correlation Coefficient	1.000	.769**
		Sig. (2-tailed)	.	.000
		N	27	27
	Confidence	Correlation Coefficient	.769**	1.000
		Sig. (2-tailed)	.000	.
		N	27	27
**. Correlation is significant at the 0.01 level (2-tailed).				

For the day group there is a strong positive correlation between perceived understanding and perceived confidence, positive correlation coefficient of 0.769, $p < 0.01$

Correlation of perceived understanding and confidence for the evening group				
			Understanding	Confidence
Spearman's rho	Understanding	Correlation Coefficient	1.000	.637**
		Sig. (2-tailed)	.	.000
		N	41	39
	Confidence	Correlation Coefficient	.637**	1.000
		Sig. (2-tailed)	.000	.
		N	39	39
**. Correlation is significant at the 0.01 level (2-tailed).				

For the evening group there is a strong positive correlation between perceived understanding and perceived confidence, positive correlation coefficient of 0.637 $p < 0.01$

APPENDIX M: Learning environments for day and evening groups (raw scores)

	Number of student responses			
Environment: Day group	**Not identified**	**Yes**	**No**	**Sometimes**
Allowed to ask questions	0	18	1	8
Encouraged to discuss answers	1	9	5	12
Allowed to work with a partner or in groups	1	12	5	9
Worked in silence	0	15	12	0
Encouraged to keep trying until understood	1	17	2	7
Worked completely alone	2	8	2	15

	Number of student responses			
Environment: Evening group	**Not identified**	**Yes**	**No**	**Sometimes**
Allowed to ask questions	1	21	5	14
Encouraged to discuss answers	1	11	15	14
Allowed to work with a partner or in groups	2	12	18	9
Worked in silence	1	26	2	12
Encouraged to keep trying until understood	1	14	12	14
Worked completely alone	2	19	5	15

APPENDIX N: Positive and negative influences in learning mathematics for day and evening groups (ranked orders in percentages)

P = positive influence N = negative influence

Day Group:

Rank	Factors	Rank	Factors
P1	Attendance at school (82%)	**N1**	Tests and exams (56%)
P2	Personal behaviour at school (67%)	**N2**	Effect of other pupils (41%)
P3	Effect of the teacher (60%)	**N2**	Personal issues outside of school (41%)
P4	Effect of other pupils (56%)	**N4**	Effect of the teacher (36%)
P5	Personal issues outside of school (30%)	**N5**	Personal behaviour at school (7%)
P6	Tests and exams (26%)	**N5**	Attendance (7%)

Evening group

Rank	Factors	Rank	Factors
P1	Attendance at school (66%)	**N1**	Tests and exams (65%)
P1	Personal behaviour at school (66%)	**N2**	Effect of other pupils (61%)
P3	Effect of the teacher (40%)	**N3**	Effect of the teacher (60.5%)
P4	Personal issues outside of school (34%)	**N4**	Personal issues outside of school (42%)
P5	Tests and exams (30%)	**N5**	Personal behaviour at school (20%)
P6	Effect of other pupils (24%)	**N6**	Attendance (17%)

APPENDIX P: Coding for qualitative comments from the pre-teaching questionnaire and sample comments

Teacher/Teaching

Setting arrangements

Personal understanding

Public nature of doing mathematics

Current role

Tests and examinations

Influences outside school

Availability of support

Behaviour

Attendance

Specific aspects of mathematics

A	As a child was expected to learn tables from two to twelve and then tested within class orally. To this day although I have a good sound knowledge, I panic at the thought of having to say out loud any answer to a maths question, even if I am secure in the answer, as the memory of having to stand up in front of the class until you had answered three questions correctly still haunts me.	↓↑↓
B	Good teacher support throughout school years – strict teacher to encourage work is complete. Being pushed at GCSE to reach my full potential allowed me to continue this at A level – although due to further workloads, struggled to grasp the concept.	↑↓
C	I was in a middle ability maths group at school and achieved a C in GCSE. I find that I can understand maths when it is explained but find it hard to remember over time. I used to have to concentrate a lot in maths lessons in order to understand but I did understand in the end so I know it is within my capability to do well.	↑↑↓

APPENDIX Q: Spearman's rho correlations for individual day and evening groups in relation to perceived understanding and perceived confidence, post-teaching questionnaire

Correlations

			Understanding	Confidence
Spearman's rho	Understanding	Correlation Coefficient	1.000	.751**
		Sig. (2-tailed)	.	.000
		N	27	26
	Confidence	Correlation Coefficient	.751**	1.000
		Sig. (2-tailed)	.000	.
		N	26	26

**. Correlation is significant at the 0.01 level (2-tailed).

For the day group there is a strong positive correlation between perceived understanding and perceived confidence, positive correlation coefficient of 0.751, $p < 0.01$

Correlations

			Understanding	Confidence
Spearman's rho	Understanding	Correlation Coefficient	1.000	.575**
		Sig. (2-tailed)	.	.000
		N	37	37
	Confidence	Correlation Coefficient	.575**	1.000
		Sig. (2-tailed)	.000	.
		N	37	37

**. Correlation is significant at the 0.01 level (2-tailed).

For the evening group there is a strong positive correlation between perceived understanding and perceived confidence, positive correlation coefficient of 0.575 $p < 0.01$

APPENDIX R: Spearman's rho correlations for individual day and evening groups in relation to comparative understanding and confidence, post-teaching questionnaire

Correlations

			Comparison und	Comparison conf
Spearman's rho	Comparison und	Correlation Coefficient	1.000	.629**
		Sig. (2-tailed)	.	.000
		N	27	27
	Comparison conf	Correlation Coefficient	.629**	1.000
		Sig. (2-tailed)	.000	.
		N	27	27

**. Correlation is significant at the 0.01 level (2-tailed).

For the day group there is a strong positive correlation between comparative understanding and confidence, positive correlation coefficient of 0.629, $p < 0.01$

Correlations

			Comparison und	Comparison conf
Spearman's rho	Comparison und	Correlation Coefficient	1.000	.318
		Sig. (2-tailed)	.	.055
		N	37	37
	Comparison conf	Correlation Coefficient	.318	1.000
		Sig. (2-tailed)	.055	.
		N	37	37

For the evening group there is a moderate positive correlation between comparative understanding and confidence, positive correlation coefficient of 0.318, $p < 0.01$

APPENDIX S: Individual group responses to Question 6, post-teaching questionnaire

Day group – summary of responses

	1 Strong negative influence	2 Negative influence	3 No influence	4 Positive influence	5 Strong positive influence
Attendance at sessions	0	0	1 (4%)	8 (30%)	18 (67%)
Teaching	0	0	0	15 (56%)	12 (44%)
Other students	0	0	1 (4%)	22 (82%)	4 (15%)
Tests and exams	1 (4%)	4 (16%)	4 (16%)	12 (48%)	4 (16%)
Online materials	0	0	5 (19%)	16 (59%)	6 (22%)
Discussion boards and blogs	0	2 (8%)	18 (69%)	6 (23%)	0
Websites	0	0	10 (39%)	14 (54%)	2 (8%)
Outside influences	0	0	16 (70%)	7 (30%)	0
Drop in sessions	0	0	12 (55%)	9 (41%)	1 (5%)
In class discussion	0	1 (4%)	1 (4%)	16 (59%)	9 (33%)
Other (please state):					

Evening group – summary of responses

	1 Strong negative influence	2 Negative influence	3 No influence	4 Positive influence	5 Strong positive influence
Attendance at sessions	0	0	2 (5%)	8 (22%)	27 (73%)
Teaching	0	0	0	9 (24%)	28 (76%)
Other students	0	1 (3%)	3 (8%)	25 (68%)	8 (22%)
Tests and exams	0	5 (14%)	7 (20%)	19 (54%)	4 (11%)
Online materials	0	0	2 (6%)	25 (69%)	9 (25%)
Discussion boards and blogs	0	0	29 (81%)	7 (19%)	0
Websites	0	0	9 (25%)	24 (67%)	3 (8%)
Outside influences	0	1 (3%)	21 (58%)	12 (33%)	2 (6%)
Drop in sessions	0	0	23 (79%)	6 (21%	0
In class discussion	0	0	1 (3%)	27 (75%)	8 (22%)
Other (please state):					

APPENDIX T: Coding for qualitative comments from the post-teaching questionnaire and sample comments

Themes

Teaching

Characteristics of the teacher

Tests and examinations

Discussion/working with others

Online materials

Personal understanding/confidence

Practice

Concepts

Confidence

Understanding

EE	I have a much more positive attitude towards learning mathematics since starting the first course. The teaching has been broken down the way each element is worked out, and this has made me have a clearer understanding of areas of mathematics that I have previously worried about or struggled with. Definitely more confident!	↑↑	↑↑
FF	I am lucky enough to understand maths quite well and I work in year five so have covered most of the topics we have looked at. By attending this course my understanding of these methods have been endorsed by the lecturer. However, I do not believe I have learned anything I did not already know and have found sessions very slow.	↓↑	→

APPENDIX U: Comparison of audit and test items

Area of coverage	Audit	Post-unit test
Place value – words and numbers	✓	✓
Calculating using the four rules	✓	✓
Word problems	✓	✓
Fractions, decimals and percentages – conversion	✓	✓
Percentage of an amount	✓	✓
Calculations with fractions	✓	✓
Calculations with decimals		✓
Rounding to a given number of decimal places		✓
Estimation		✓
Substitution	✓	✓
Simplification of expressions	✓	✓
Solve simple linear equations	✓	✓
Working with simple sequences		✓
Conversion between units of measure	✓	✓
Area of rectangle	✓	✓
Area of triangle	✓	
Volume of cuboid	✓	✓
Surface area of a cuboid		✓
Reflective symmetry	✓	
Measures of central tendency	✓	✓
Pie charts	✓	
Frequency table	✓	✓
Bar chart	✓	✓
Scattergraphs		✓
Correlation		✓
Interpreting data		✓
Simple probability	✓	✓

APPENDIX V: Progress data for the day and evening groups

Day group	Audit percentage scores June 2011	Test Percentage Scores 2012	Difference
NN	70	60	-10
OO	78	71	-7
PP	42	36	-6
QQ	84	79	-5
RR	76	72	-4
SS	54	52	-2
TT	66	65	-1
UU	84	84	0
V	96	97	1
WW	80	82	2
XX	88	92	4
YY	48	52	4
ZZ	70	79	9
AAA	58	68	10
BBB	86	96	10
CCC	88	98	10
DDD	84	97	13
EEE	76	90	14
FFF	58	73	15
GGG	78	93	15
HHH	60	75	15
III	84	99	15
JJJ	74	90	16
KKK	50	68	18
LLL	48	67	19
MMM	44	65	21
NNN	34	59	25
OOO	60	87	27
PPP	58	86	28
QQQ	32	63	31
RRR	60	92	32
SSS	36	76	40

For the day group, students scoring over a +10 percentage points difference between the audit in 2011 and the unit test in 2012 were invited to participate in the focus groups. Those highlighted in yellow volunteered to take part.

Evening group	Audit percentage scores June 2011	Test Percentage Scores 2012	Difference
A	66	60	-6
B	96	95	-1
C	58	60	2
D	64	66	2
E	92	95	3
F	88	91	3
G	76	80	4
H	76	82	6
I	80	86	6
J	88	95	7
K	76	83	7
L	64	72	8
M	88	97	9
N	66	75	9
O	80	93	13
P	46	60	14
Q	80	94	14
R	74	89	15
S	74	89	15
T	70	86	16
U	64	80	16
V	68	85	17
W	56	73	17
X	66	84	18
Y	48	69	21
Z	54	77	23
AA	56	80	24
BB	58	82	24
CC	18	43	25
DD	60	85	25
EE	54	79	25
FF	40	67	27
GG	32	59	27
HH	26	54	28
II	40	70	30
JJ	46	79	33
KK	46	83	37
LL	26	78	52
MM	8	74	66

For the evening group, students scoring over a +15.5 percentage points difference between the audit in 2011 and the unit test in 2012 were invited to participate in the focus groups. Those highlighted in yellow volunteered to take part.

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