Mature non-specialist undergraduate students and the challenges they face in learning mathematics

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Abstract

This research uses a case study approach to examine the learning experiences of mature non-specialist first year undergraduate university students studying mathematics as an ancillary subject. The challenges faced by such students taking mathematics as a subsidiary subject within their main degree have not been adequately addressed in the literature: this study seeks to address this gap.

The research took place in a UK inner-city post-1992 university which has a very diverse student intake. A qualitative data set was generated from in-depth and focus group interviews of 22 mature students, the majority of whom were non-specialists taking mathematics as a required ancillary subject. An additional quantitative data set was derived from a questionnaire distributed to 250 students taking first year mathematics modules, either as an ancillary or as a specialism subject. A small number of mature students specialising in mathematics in both the interviews and the survey were included in order to compare the experiences and views of the both specialist and non-specialist groups. The Mixed Methods Research Design adopted combined results from the qualitative and quantitative analyses, and was accompanied by a poststructuralist theoretical framework which examines the discursive practices students were exposed to in relation to their construction of mathematics as a subject and their experiences of learning mathematics.

The study shows that the major perceived factors that affect mature non-specialist students learning of mathematics include the pedagogical model that is used; the attitudes and beliefs of the learners; the support available to aid learning; and the prevalent discourses about the learning and perceptions of mathematics. These findings have a number of important implications for policy and practice for teaching mathematics to such students, for our understanding of student identities and for widening participation. The evidence from this study suggest that there should be a shift of government policy on access and financing for mature students; a review of mechanism of financial support for mature students; changes in the organisation and resourcing of small classes; a review of curriculum and pedagogy to fit the diverse background of learners; and the development of mathematics support provisions that are embedded in courses that require mathematical skills.

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Dedication

I have the pleasure of dedicating this work to my loving wife, ***Tsige Birru-Benti,*** *who battled with Cancer and survived to see the completion of my research. I thank God who I believe made this possible for us.*

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CHAPTER ONE

Introduction

1.1 Background to the research

This thesis using a case study approach explores the factors that affect the learning of mathematics by mature non-specialist first year undergraduates, who are taking mathematics as an ancillary subject for their degree courses.

Mathematics as a subject is perceived by those learning it in many different ways. Some have a negative perception (such as it being strange, boring, difficult, hated, a source of anxiety and fear, etc.) while others have a positive perception (seeing it as a subject that provides an insight into the world, elucidating relationships between the mathematical and the physical worlds, helping to develop logical thinking, being a collection of skills for life with wide application, etc.). Boaler (2009:1) proposed that ‘mathematics plays a unique role in the learning of most children - it is the subject that can make them feel both helpless and stupid’ and negative feelings such as these could be carried over to adulthood, to the extent of avoiding mathematics in the academic menu they would have in studying for their future career and life.

My research investigates the beliefs of a group of first year undergraduate students about how their experiences contributed to their learning of mathematics at university level. In order to understand the basis of their beliefs, it was necessary to look at a ‘model of people’s lives’ (Barton, 2008), the way they live and learn, and in particular at the values and assumptions they have about mathematics. These students have diversified background and their own histories to tell, which provide a basis for their particular perceptions of mathematics. To understand the impact of their experiences on their learning, this thesis examines the ‘discourses that constitute’ mathematics (Foucault, 1972:49) that circulate through schools, teachers, parents, the media and society at large; such a discourse constitutes a distinct form of communication within a community (Sfard, 2008). I have examined discourses[1] related to mathematics and the resulting discursive practices (meanings that are formulated and understood) that position/subject learners according to existing power relations ‘by which individuals try to direct and control the conduct of others’ (Foucault, 1997:298) and their construct of identities related to mathematics.

My investigation was carried out with first year undergraduate mature students who returned to university education after an absence of at least one year from formal secondary education. Students 21 years or over are categorised as mature students in the UK (Evans, 2000; HESA, 2011a) and are labelled ‘non-traditional’ (Leathwood and O’Connell, 2003: 599). The label may be used to refer to students with long-term disability, students from working class background, students from the minority ethnic groups and students who come back to higher education through alternative routes other than the traditional A-levels (for example Access Courses) and may be ‘pathologized as being deficient in ability, academic background and attitudes’ (*ibid*). However, in this thesis the term non-traditional[2] is used to indicate students defined by HESA as mature. As the title of this thesis indicates, the focus of my study was on mature non-specialist students taking mathematics as an ancillary subject required for their degrees. These students did not take mathematics because it was their favourite subject and they loved doing it; or because they believed its usefulness in their courses and they wanted to do it – rather they were *obligated* to do it by the education system. This issue will be discussed in

[1] The terms discourse, discursive practices, subject and power are explained and their usage in the thesis explained in Chapter Two.
[2] Throughout the thesis the terms ‘non-traditional’ and ‘mature’ and ‘traditional’ and ‘younger’ are used interchangeably.

detail in the data analysis chapters. From my experience as a teacher, a considerable proportion of such mature non-specialist students show frustration and appear to be challenged by mathematics. Some even opt to or are forced to discontinue their education; there is research evidence to suggest that mature students have a higher dropout rate than those under the age of 21 (Arulampalam, *et al*., 2004; NAO, 2007). The overall student retention statistics available from the Higher Education Statistics Agency (HESA, 2011b) show that in the academic year 2009/10, in England, 90.5% and 84.7% of the traditional (under 21 years old) and non-traditional (21 years and over) students respectively had continued their education to the next year. The retention and pass rates for the non-traditional students are much lower than those of the traditional students. Nevertheless, this difference may not be explained by only drop out statistics thus justifying an investigation. However, as pointed out earlier I concentrate on mature non-specialist students taking mathematics for which retention statistics or drop-out rates have been proved hard to find.

The challenges encountered by many learners of mathematics have been given attention by many researchers and writers. For example, research on primary and secondary pupils and undergraduates whose main subject of study is mathematics has been considered by Galbraith and Haines, 2000; Richardson and Woodley, 2003; Solomon, 2006; Britton, *et al*., 2007; Steyn and Du Plessis, 2007; Mahir, 2009; Solomon, *et al*., 2011; Parsons, *et al*., (2009; 2011) and Croft and Ward (2001) studied university engineering students doing mathematics for their degree courses; Sabin (2002) looked at the lack of mathematical skills among student nurses; students studying maths as a supporting subject for computing degree courses were studied by Warwick (2008); Sutherland and Dewhurst (1999) looked at the mathematical background of students doing a wide range of disciplines such as Chemistry, Biology, etc.; and some work on first-year bio-science students has also been done by Tariq (2002). However, most of the research on mathematics at university level has been on 'traditional' white middle-class 19-year-old students, who have just completed their A-levels and then joined universities to read mathematics (Zevenbergen, 2001).

The profile of students joining universities has changed in the last eight years (ECU, 2012) particularly in post-1992 universities as a consequence of the implementation of the policy of widening participation (Leathwood and O'Connell, 2003); and a large majority of undergraduates are now highly diverse in terms of age, gender, class and ethnicity (Kitchen, 1999; Morey, *et al.*, 2003). Woodley (1984), Kasworm, *et al*. (2002) and Galligan and Taylor (2008) describe a situation in which many mature people in the UK, the USA and Australia begin taking degree courses after a period of absence from formal studies. HESA (2010) reported that 58% of all the students in the UK who were admitted to study for first degrees in 2009/10 were aged 21 or over.

Reay, *et al*. (2005) argue that the expansion of higher education in the UK in the 1990s was made possible by the initiative taken to attract mature students back to education, and as a result the entry of mature students to higher education rose. In addition, to boost the supply of students studying at university level and qualifying in HE subjects, the government adopted a policy of widening participation in higher education, so that by 2010 at least 50% of the young people aged below 30 years would take part in higher education (Newby, 2004; Reay, *et al*., 2005); the target has yet to be met in 2012 (DfE, 2012). This policy particularly targeted young people from under-represented social groups in universities, including mature students, with the potential to benefit from such a policy (Watts, 2006). However, as pointed out by Sabin (2002) widening of the entry gate to HE has fostered new demands. Nevertheless, as described in the studies mentioned above, the academic challenges faced by mature non-specialist first year undergraduate students have not been given sufficient attention. As pointed out earlier research evidence support that mature students have a higher dropout rate than traditional students and there is concern about the widening participation policy, as those universities with the most success at widening participation also experience high drop-out rates (Reay, *et al*., 2010). Furthermore, the policy of widening participation has led to an expanding diversity in the mathematical skills and ability of students; and Sabin (2002:15) indicates that 'some students in HE demonstrate a numeracy skills deficit'. Consequently, non-traditional students, including those who have not necessarily chosen to study mathematics but are obligated to do it, need to be studied with regard to their perceptions of the challenges HE mathematics modules offer them.

Arguing that it would make the UK competitive with other economies, the UK government developed a strategy to increase the supply of scientists, engineers, technologists and mathematicians in the late 1990s. Together with other members of the European Union, a key policy focus of the government has been on increasing the uptake of STEM (Science, Technology, Engineering and Mathematics) subjects by young people, to meet the demand by the labour market for qualified graduates in the STEM subjects (European Commission, 2002; DfES, 2006). Mathematics, as one of the STEM subjects, is considered to be strategically important, but 'vulnerable', in that it does not attract enough young people to learn and obtain qualifications (Rodd and Bartholomew, 2006).

The government also gave importance to work-related learning that enabled graduates to have the right skills to achieve life-long employability. As noted by CBI (2008) and Durrani and Tariq (2012), one of the skills sought for lifelong employability is the application of numbers, a 'use of basic mathematical operations with confidence in practical situations' (Evans, 2000:3). The effect of not having a mathematical fluency in subjects that require a level of mathematical ability on the students covered in my investigation is explored in later chapters.

In the shift of teaching provision towards vulnerable STEM subjects, mathematics in particular is being encouraged by these various policies highlighted above. The present Coalition Government continues the previous Labour government's commitment to these policies, for example confirming that the STEM disciplines continue to receive some direct subsidy from the government (Cable, 2010). However, as Croft and Ward (2001:197) point out the diversity in ability of the students and the lack of interest to study mathematics and the limited resource made available have been the source of challenges both for the academic staff and the students. And, the government's policies do not appear to address or acknowledge this source of challenges in teaching or learning mathematics at HE level. Arguably, mature students who have taken up the opportunity of re-entering education at a higher level are likely to face different and additional social challenges (for example, changes of roles of the gender in the family, issues related to finance, etc.) from younger students; they probably have different mathematical backgrounds, and these differences might affect their learning and impact on their 'performances' (Schoenfeld, 1992; Crawford, *et al*., 1994; Carlson, 1999; Anthony, 2000; Cox, 2001; Parsons, 2005; Solomon, *et al*., 2011). Smith (2008) points out that although the experiences and success of mature students in higher education differ from their counterparts, younger students, there appears to be little research evidence specifically addressing issues related to mature non-specialist students. These developments form the background to my research into the experiences of mature non-specialist students doing mathematics at HE level.

1.2 The study

In order to carry out my investigation I focussed on a case study institution which would provide a setting to explore in depth the issues and concerns of this thesis. Within this institution, I focussed on particular participants located within particular disciplinary and subject as source of data (information). In what follows I provide detailed information on the participants, institution and its social and geographic location to set the context for the analysis that follows.

1.2.1 The participants

My research is focussed on mature non-specialist students who were obliged to study mathematics as an ancillary subject that was required for their degree. The type of information sought is of a qualitative and a quantitative nature, obtained by interviews (qualitative data) and survey (quantitative data). The interview participants were recruited specifically so that all were mature students (aged 21 or over), of whom 73% were non-specialists doing either Business or Biomedical courses and the remaining 27% were Mathematics specialists. The composition of the participants in the survey was representative of the broader cohort of students at the institution: 60% were mature and 40% were below 21 years old. Although the focus of my research is on mature non-specialist students, I have intentionally included a small fraction of mature and mathematics specialist students to take part in the study to allow a comparison. This is made clear and elaborated on within the data analysis chapters.

As part of my professional role as a university lecturer, I have been involved in teaching first year undergraduate students two core mathematics modules: Quantitative Methods (QM) and Data Analysis (MA) for more than ten years. The mode of teaching has been a two hour lecture followed by up to two hours of tutorial or workshop sessions. Maths

Clinic, a mathematics support/drop in sessions is available to all first year students throughout the academic year in the two campuses of the university. I was available to the QM students only once in the week when I lectured and gave tutorials; while I was available to the MA students most days of the week. However some of the mathematics support sessions were poorly attended during the teaching weeks. The majority of the students in both the QM and MA modules were mature students. The Business students took the QM module and the MA module was taught to both Biomedical and Mathematics students together until 2009/10 academic year. After this, based on my recommendation (detail given in Chapter Eight), this module was taught to the two groups separately.

Table 1.1 shows the end of term performances of the QM and MA students in the years indicated. The minimum pass mark was 40% in both modules. Students who failed these modules were eligible to take a re-sit in the summer term when many more students attended the Maths Clinic.

Table 1.1* **Performances of QM and MA students for selected years**

QM Students					MA Students			
Year	**No. Students**	**% Pass**	**% Fail**		**Year**	**No. Students**	**% Pass**	**% Fail**
2007/08	86	77	23		2007/08	203	85	15
2008/09	69	71	29		2008/09	235	77	23
2009/10	55	62	38		2009/10	248	84	16

(*Source: e-vision and module-logs of the university*).

1.2.2 The institution

I found it practically convenient to conduct my investigation in the institution I have been working as a senior lecturer in mathematics and statistics, where I could easily choose students who are potentially suitable for my investigation. In addition, given the particular emphasis of the Ed D on reflective practice, conducting the research in my own institution enabled me to reflect critically on my professional identity and practice within higher education. Although this choice of research site to conduct the research is valuable, it raises ethical dilemmas and challenges which I have addressed in the Research Methods chapter. I give a brief description of the location, catchment area, ethos and other relevant aspect of the institute.

- **Location of the campuses**

The university is a post-1992 university with two major campuses, called here Campus A and B, where courses related to computing, science and social sciences are offered in Campus A while courses related to finance, accounting, business studies and the arts are offered in Campus B. Campus A is located in a borough where both high levels of deprivation and pockets of very affluent, middle class professionals and families live; many people in this borough earn well below the average national income and the majority live in social council properties or private accommodation. Campus B is located in a prime area in London, surrounded predominantly by office buildings and large business firms. My office was in Campus A and I travelled to Campus B to lecture and provide the tutorial sessions which were scheduled to run at the same day. If the QM students from Campus B needed any help from me during the week they had to travel to Campus A.

As pointed out by Thomas (2002) many students prefer flexibility when choosing accommodation at university, this includes more independent living, with the option of self catering, to have a homely environment with flexibility and support. However for many non-traditional students the choice of accommodation is dictated by other factors that arise from their additional social responsibilities. However, London allows students to find the living arrangements that best suit them and a choice of location to pursue their university education; and as a result most of the students of this university live at home and save money. The students in this particular university benefit from its location where temporary, evening and seasonal jobs are available.

- **Catchment area**

The university has a population of about 25,000 students in the two campuses. The university is unusual in that it has a large student body most of whom are not traditional 19-year old students. Many are much older; their backgrounds tend to be much poorer and with a less academic background when compared with other universities. Data extracted from HESA (2011b) show that, for example in the academic year 2009/10, almost half of the students in this university were from minority ethnic communities, compared with 15% of the student-population nationally. Of the full-time undergraduate entrants to the university, about 55% were mature compared with only 21% nationally; well over 90% of the students of this university were from state schools or colleges compared with 88% nationally; and over 40% of the students were from socio-economic groups 4(Small employers and own account workers), 5(Lower supervising and technical occupations), 6(Semi-routine occupations), and 7(Routine occupations) when compared to 31% of the student-population nationally. The students' non-continuation rate as extracted from the performance indicators from HESA(2011b) show that nearly 25% of the 2009/10 entrants to this university did not continue to the next year while the national rate for non-continuation in the same year was less than 10%. The students' non-continuation rate and the possibility of them dropping out or taking longer to complete their courses have been issues for this university, as in many post-1992 institutions.

- **Ethos of the university**

This post-1992 university is committed to providing HE courses to all segments of society and from varied social and socio-economic backgrounds, with a focus on both young students who have underachieved due to their social circumstances and on mature students who did not have the opportunity of attending university courses; socially excluded and at risk groups including disabled and ethnic minorities. The access policy to the university's courses is guided by the widening participation principle where admission of applicants to the university's courses was based on **ability to benefit**[3] rather than the ability to succeed in a course**.** The university, within the framework of widening participation, also provides fair access to its wide variety of undergraduate courses to candidates from the non-traditional group of students who do not strictly meet the normal entry requirements to some of its courses. The university has access routes to its courses for students who come from a diversified background; for example, students are given the opportunity to do Foundation courses, etc. before joining the main courses. The university has courses tailored to address educational learning needs of students so that they could attain their potential and improve their achievement; enhanced access pathways for mature students to become engaged in HE courses. Underpinning the ethos of a stated commitment to providing students with quality and standards, the university, in 2011, was awarded the highest grade from the government's Quality Assurance Agency (QAA) review. It also received a large amount of money from the funding agency for its widening participation activities, the funding being based on the number of students deemed to be in the widening participation category. The university's widening participation programme includes collaborative partnerships with communities and attracts a large number of mature students.

[3] This policy has been changed recently as explained on pp. 183 – 184.

Many students value the institution, as the following quote[4] from a letter by a former mature non-specialist student who lived in the borough where the university is and who went to the university to do undergraduate studies show:

> I work part time and would not be able to flourish in the same way without this particular course at this particular university. There weren't any other options for someone like me, who is a bit older than the average graduate, and returning to further education. This course and in fact all the other courses available at the university are like a jewel in a whole ocean of courses and colleges. *(name of the institution with-held*) allows access to education for people from all walks of life who would not normally be able to get a place in education at this level.

1.3 The aim and rationale of my research

As I argued in Section 1.1, the particular group of mature non-specialist students has been neglected in both government policy terms and in academic literature. Furthermore, first year mature non-specialist students doing mathematics as an ancillary subject are likely to have different mathematical- and general learning- experiences from those of traditional students, a factor which HE policy and education providers have not fully considered. Consequently, the existing academic practices (which are intended mainly for the 'traditional' students) may not fully meet the academic needs of mature students. The aim of my study is, therefore, to develop a greater understanding of the perceived factors that affect mature non-specialist undergraduate students when learning mathematics as an ancillary subject, and to examine the contribution of their experiences towards their approach to learning mathematics at a university level. In order to achieve this aim, I focused on a main research question:

[4] The facts mentioned in this section were extracted from documents available from the university's archives and other literature accessible for the public consumption, (for example information from HESA).

Why do some mature non-specialist undergraduate first year students taking mathematics as an ancillary subject find mathematics challenging and fail to pass it?

To address this, I carried out research with mature non-/specialist undergraduate students through biographical data collected from purposively-selected participants doing first year mathematics modules as a core module. My line of inquiry addressed specific questions on the construction of mathematics by different agents, such as teachers and society (McIntosh, 1978; Davies, 1990), and the impact this had on the learners in their belief of their ability to comprehend mathematics.

1.4 Nature and analysis of the research data: an overview

The main objectives of my investigation can be articulated as follows:

a. To contribute to knowledge regarding the learning of mathematics by mature non-specialist students
b. To contribute to institutional policy and practitioner knowledge and practice so as to better support the needs of mature non-specialist mathematics students

In order to achieve the objectives of my investigation, I collected data in two stages: in the first stage, I conducted semi-structured in-depth, one-to-one and two focus groups qualitative interviews on two cohorts (2008/09 and 2009/10 entries) of first year undergraduate students to explore the participants' experiences while learning mathematics at pre-university level, their perception of mathematics and how they positioned themselves when learning mathematics. At this stage, in total a sample of 22 mature students (of which the majority 73% or 16 individuals were non-specialists) took part in the one-to-one and focus group interviews. The procedure used to choose the sample is discussed in detail in the methodology section of Chapter Three. In the second stage, quantitative data was collected from 250 undergraduate first year students doing mathematics, using a questionnaire constructed on the basis of the themes generated from the analysis of the interviews[5]. The respondents in the questionnaire were a subgroup of first year students, non-/traditional and non-/specialists, doing a mathematics module in the academic year when the research was undertaken. One of the purposes of the questionnaire-based data was to examine if the themes, generated from the interviews, were widely held by the majority of the students covered by the study.

The data obtained from the participants of the interviews and respondents of the questionnaire were analysed using qualitative and quantitative techniques as described in the data analyses Chapters Four through Seven. As described in Chapter Three, drawing on the principles of sequential exploratory Mixed Methods Design (Gorard and Taylor, 2004; Morse and Niehaus, 2009; Creswell, 2009), the results from the qualitative and quantitative analyses were integrated at the interpretation phase in order to address the research question. The order of the data production and the analyses performed on the data produced are shown diagrammatically in Chapter Three (p.64).

A theoretical framework underpinning the study was essential (Zuber-Skerritt, 1992) and an interpretive paradigm framework was employed to identify and understand the diverse experiences and stories as reported by the participants. My investigation is focussed on discourses related to mathematics and the impact on the learners of the discursive practices that have resulted from such discourses. I argue that post-structuralism is a suitable theoretical framework to underpin my investigation. This is because it offers very different ways of looking at, and beyond, the reasons for particular responses; it identifies the

[5] The rationale for the first qualitative phase is that the area being investigated is under-researched as explained in Section 1.1 and needs to be explored and then studied further in the second phase.

discourses that positioned the learners of mathematics and how the learners positioned themselves within the prevalent discourse and constructed their identities. Further discussion is given in Chapter Two regarding my choice of post-structuralism as a theoretical framework for my investigation.

1.5 Organization of the thesis

The thesis is organized in eight chapters including this scene-setting Chapter One where the institute in which the research was undertaken, the main research question, the aims and objectives of the research have been introduced and an overview of the data production and methods of analyses given.

The rationale for my choice of post-structuralism as a theoretical framework is given in Chapter Two and I provide critical review of the relevant and related literature on mathematics learning and learners' identities. The literature review under different emerging themes summarizes what is so far known about the learning of mathematics relevant to my specific interest. Some of the themes are around the positioning of mathematics in the curriculum; the construction of mathematics; the pedagogy and the impact on the learning of mathematics of social class, gender and ethnicity of the learner.

The research design, methodology including sampling procedures, detailed data production methods and analysis techniques used in the investigation are introduced in Chapter Three. The chapter also addresses the limitations of the research design and the potential ethical issues relating to accessing the participants/respondents. The measures taken in order to recognize and address the possible impact of a personal epistemological position when interpreting the results are also highlighted.

Chapter Four describes how the qualitative data collected from the one-to-one and focus group interviews; and the survey data collected from the questionnaire data analyses were conducted. The pattern of responses to the survey questions and the impact of the categorical variables age, gender, ethnicity and course of study on the respondents to the survey questions are examined using General Linear Model (GLM) and Logistic Regression analyses. Each of these analyses is performed independently and then the results integrated based on the principals of Mixed Methods Research. The integration of the results and how the analyses led to the identification of the factors perceived to affect the learning of mathematics are demonstrated.

The results of the analyses of the qualitative data collected from the interviews and the focus groups are presented in Chapters Five to Seven. The qualitative data set was analyzed thematically and the emerged themes within discourses are linked to the constructed components from the quantitative data analysis presented in Appendix 4. Accordingly, in Chapter Five, the components from the Principal Component Analysis (PCA) related to Pedagogy and the Attitude of the learners towards mathematics learning, are explained and mapped onto the issues already identified from the qualitative analysis. A similar procedure of mapping the components from the PCA related to Support available to the learners of mathematics; Beliefs about mathematics; learners and other people's Perceptions to issues already identified from the qualitative analysis are dealt with in Chapter Six. In Chapter Seven, components from the PCA related to issues concerning Ethnicity and Gender of the learner are mapped onto the themes emerged from the discourses identified in the one-to-one and focus group interviews.

In Chapter Eight, the key findings of my investigation are summarized and the conclusions presented. I highlight the implications of the research for policy, practice and research communities: I identify the possible changes brought by implementing the findings from the case study about the teaching of first year mathematics module for mature non-specialist students and suggest areas of consideration for future research. I also reflect on the extent to which my investigation addressed the main research question and its limitations with the evaluation of the research design.

CHAPTER TWO

Literature Review

2.1 Introduction

This chapter presents the theoretical framework and the key fields of literature that this research engages with and seeks to contribute to. This review is organised according to the themes that emerged from the literature: the way mathematics has been constructed by those who design the curriculum in general; the way that learners construct mathematics; the pedagogy used to deliver the subject; and the impact on the learning of mathematics of some of the constructed identities of the learners, for example, their gender, ethnicity and social class. In this review, I endeavour to identify the ways in which this literature contributes to my study. I begin with describing the theoretical framework employed in my study.

2.2 Theoretical framework

This study utilises a poststructuralist theoretical framework to help understand the construction of mathematics through the experiences of the mature non-/specialist learners of mathematics.

There are various stories about mathematics that circulate between schools, teachers, parents, the media and the society at large. These stories form a 'discourse' (a particular way of talking about mathematics) and people position themselves within this discourse. Positioning can be seen as the process by which individuals are made to assume specific roles through discursive practices[6] or adopt a role. Discourses regulate the process of positioning and being positioned which is defined as 'subjectification' (Mendick, 2006*:*

[6] 'discursive practices' are the meanings that are formed and understood.

24) and so subjectivity is produced through available discourses. Also, identities that are a sense of self are 'constructed out of discourses culturally available to us... [and] the discourses that form our identity have implications for what we can do and what we should do' (Burr, 1995: 51-54) thus creating a power relationship. This means discourses carry power in 'their ability to position things and people as negative or positive, powerless or powerful' (Francis, 2000a: 19). In other words, discourses make it possible for individuals to articulate what they believe/think, for example, 'I am good in mathematics' or 'mathematics is a difficult subject'; and provide taken-for-granted ideas and ways of practices.

In this thesis I explored how discourses about mathematics could make mature non-/specialist undergraduate students studying mathematics assume certain positions while learning mathematics; how these discourses shape students' beliefs about themselves and construct their identity of engagement in relation to mathematics as a subject; how the different attitude towards mathematics is constructed; how the power relations between students and tutors contributed towards their learning of mathematics. Poststructuralist theory recognises the force of discursive practices, the ways in which people are positioned and position themselves through those practices, and the power relationship in which 'the individual's subjectivity is generated through the learning and use of certain discursive practices' (Davies and Harre, 1990:43). Furthermore, Davies (1993: 13) points out that 'in poststructuralist theory the focus is on the way each person actively takes up the discourses through which they and others speak/write the world into existence as if it were their own'. As pointed out by Davies (1993:46), once having taken up a particular position as one's own the learners will find themselves, for example, sticking to their belief that they will fail the subject.

There are increasingly complex roles in which mature students are involved: for example, mature students could have their own families, be parents or assume the role of parent-ship; undertake part-time work to support themselves financially; have other commitments such us looking after ill parents or performing domestic chores, etc. These roles are obligations, removing choice in managing the 'multiple selves' for mature students (Hill and Stephens, 2005). In order to make learning meaningful, relevant and effective, it is necessary to understand the multiple selves of the learners. In addition, Tusting and Barton (2003: 32) point out that 'learning is intrinsically social and hence we need to understand what is going on in the social setting in which learning takes place'. This is because, the social settings produce the individual's subjectivity where, according to Davies (1994:3):

> Our subjectivity is in part the result of our particular life histories of being in the world. But our experiences of that life history, even the life history itself and how it unfolds and is told, are the result of the interactions of discourses, storylines and relations of power.

So the way the learners are positioned and position themselves in the day-to-day activities that need to be fulfilled play a significant role in their learning of mathematics. Drawing on poststructuralist theory, I analyse the socially-constructed contradictory 'multiple selves' of first year mature non/specialist students and its impact on their learning of mathematics.

Cultural discourses in mathematics position mathematics to be one of the 'hard sciences' and a 'masculine subject' (Walkerdine, 1998:154; Mendick, 2005:217); these identify mathematics with masculinity and 'count out girls' from mathematics. The construction of mathematics as a masculine subject, 'has the high-status traits of rationality and objectivity which are historically associated with the masculine' (Mendick, 2006: 68). The image of mathematics being 'a masculine subject' can create barriers for the female student. That is, despite their ability to study mathematics, in relation to this discourse girls may position mathematics to be not their subject, and position themselves as ‘not belonging in the world of mathematics’ (Solomon, 2012:171). Drawing on poststructuralist framework, I examine the cultural and dominant discourses mature students take up in order to construct their identity and subject themselves to the stated construction of the position of mathematics.

Drawing on cultural and social theory, some studies have attempted to explain the difference in ability of girls and boys in mathematics as a consequence of genetic differences (Noble *et al.*, 2001). I employed poststructuralist theory to understand and explain how the nature-and- nurture discourse surrounding gender differences in ability to do mathematics might operate in the students accounts of themselves and others and position the participants to be outside of mathematics; and the deficit discourse that made the learners blame themselves for not being ‘good’ at mathematics on the basis of attribution theory (Grouws and Lembke, 1996).

Studies have shown that the social and cultural backgrounds of learners of mathematics are determining factors, whether or not they perform to a level considered successful (Schoenfeld, 1992; Zevenbergen, 2001; Gutierrez and Rogoff, 2003). Research in this area often suggest that there is a causal relationship between the extent of social bonds within families and communities, on the one hand, and learner’s achievement and their future economic prosperity, on the other (Putnam, 1995). Learners could get support from social networks, relatives, friends or peers and relationships based on trust (generally termed as ‘social capital’), or knowledge, skills and other cultural acquisitions (‘cultural capital’). Social capital, according to Bourdieu (2007:88), arises from membership of a group; it is ‘the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalised relationships of mutual acquaintance and recognition’, while cultural capital refers to the tradition, norms, values and everyday practices of particular societies and social groups (Field, 2003). I employ social theory to understand the social and cultural capitals that learners draw on to construct their position while learning mathematics. Following this, I present a review of the literature on the way mathematics has been constructed by those who design the curriculum.

2.3 Construction of mathematics in the curriculum

Positioning mathematics involves the process of the ongoing construction of the subject through discourses; and discourses about mathematics reveal that mathematics is a worldwide phenomenon taught using a variety of methods covering similar topics. For some it is positioned as 'a universal language' (Whiteford, 2009), and as one of the 'important subjects' because of the way it is constructed by the society, as the Cockcroft (1982:1) report indicates:

> There can be no doubt that there is general agreement that every child should study mathematics at school; indeed, the study of mathematics, together with that of English, is regarded by most people as being essential... [t]his suggests that mathematics is in some way thought to be of especial importance.

The discourse of positioning mathematics as a subject having especial importance gave rise to debates among educators on the rationales of teaching it. The two dominant views are 'utilitarian', that mathematics can be taught as a service subject for other subjects, or as 'a discipline in its own right' (Hoyles, *et al*., 2001). The various inquiries carried out by past and present governments in the UK implicitly recommended a utilitarian approach. For instance, the major inquiry led by Lord Cockcroft was set to find out, among other things, why many children lack basic computational skills. The study recommended the adoption of a problem-solving approach to the teaching of mathematics (Cockcroft, 1982). A similar inquiry into mathematics education post-14 year old was carried out by [Professor] Adrian Smith. The report acknowledged the importance of mathematics for the economy, science and technology, industry and work place (Smith, 2004), implying that mathematics should be taught as a utilitarian subject.

The National Curriculum Council gave additional justification for the status mathematics holds: ‘Mathematics provides a way of viewing and making sense of the world. It is used to analyse and communicate information and ideas and to tackle a range of real life tasks and real life problems’ (NCC, 1989: A2). In addition, Kounine, *et al*. (2008) argue that mathematics is an important instrument to help develop fundamental skills of logical and critical reasoning, train the mind to conceptualise and to abstract. Similarly, Bramall and White (2000) point out that mathematics as a subject enables learners to probe the natural universe and develop new technologies to help understand the environment, change the world outlook and improve standard of living.

These positionings of mathematics might be questionable in the context of much of the mathematics teaching to young learners at school, which has been seen to lack creativity and put emphasis on rote learning (Boaler, 2009). And according to the charity National Numeracy the proposed reforms of the mathematics curriculum by Michael Gove, the current Secretary of State for Education, put too much emphasis on rote learning and very little on using mathematics in real-life situations (Vasagar, 2012). Cyril (1996) warned that the status given to mathematics could be in conflict with social justice issue unless it is made ‘inclusivist’, to be accessible to all members of society. Moreover, Gumport (2000: 68) points out that, due to the position given to a utilitarian type of mathematics teaching, ‘universities have been reorganized along a utilitarian trajectory’ and so need to make changes to their curriculum to fit the students. Likewise, Newman and Jahdi (2009) point out that the measures taken by the policy makers (to position mathematics as a utilitarian subject) have been advanced by the neoliberal ‘marketization’ policy of education where it is seen to be a commodity and the students as customers; institutions now have to market their courses (McCaig, 2011; Graham, 2013).

The literature cited above offers the basis for the dual positioning of mathematics and has implications and relevance to the group of students under my study. As the literature shows, the discourses that position mathematics to play two contradictory roles make the teaching and learning of mathematics problematic. Mathematics positioned as a utilitarian subject will be taught with the intention of equipping learners to solve problems, thus encouraging students to rote learn techniques with little understanding of the concepts involved. On the other hand, mathematics positioned as a 'discipline by its own right' will be taught by putting emphasis on abstraction, thus encouraging students to explore further and deeper. The positioning of mathematics by the curriculum also plays a significant role on the ways in which learners construct the subject as the review below shows.

2.4 Construction of mathematics by learners

The term 'belief' may be thought of as 'lenses that affect one's view of some aspect of the world or as dispositions toward action' (Philipp, 2007:259). Belief normally involves a commitment to some sort of 'factual' statement; it can be conceived as cognitive in structure and according to McLeod (1992) and Evans (2000) it also functions as one of the three affective factors (a wide range of feelings and moods). Both teachers and learners of mathematics have beliefs about mathematics that could affect the learning process. The beliefs that learners have about mathematics play a significant role in how they construct mathematics and identify with the subject. I reviewed some of the literature related to the construction of mathematics and the beliefs that mature students bring with them about the nature of mathematics. Schoenfeld (1992:359) identifies the following typical beliefs about the nature of mathematics that undergraduate students bring with them from their past education:

> Mathematics problems have one and only one right answer; there is only one correct way to solve any mathematics problem - usually the rule the teacher has most recently demonstrated to the class; ordinary students cannot expect to understand mathematics; they expect simply to memorize it and apply what they have learned mechanically and without understanding; mathematics is a solitary activity done by individuals in isolation; the mathematics learned in school has little or nothing to do with the real world; formal proof is irrelevant to processes of discovery or invention.

Such a discourse about the nature of mathematics not only discourages learners but stops potential enjoyment of the subject. Sutherland and Dewhurst (1999) noticed a fear of numbers being exhibited by the group of students under their study. Furthermore, according to Dossey (1992), the perception of the nature of mathematics held by a teacher may have a great deal to do with the way in which it is characterized in classroom teaching. Dossey points out that the way mathematics is communicated and presented to its learners affects the way the learners construct mathematics and its role in the world. As the following studies show, teachers' views about mathematics influence not only how they teach but also the attitudes of their students to learning; the learning activities students experience and develop their identities as mathematics learners.

Forgasz (1995) explored the relationship between attitudes to mathematics and classroom environment factors using quantitative data collected from a large sample of 12-13 year old pupils. The study showed that the perception of particular classroom environment factors (including student-teacher interactions and activities in the class) were linked with the functional beliefs of the individual students regarding mathematics and themselves as learners of the subject. In addition, discourses about mathematics and the discursive practices within mathematics departments (for example, encouraging students to continue studying mathematics, level of dedication to all students) were found to play a vital role in shaping the construction of mathematics by young learners, as the research carried out by Gutierrez (1996) has shown. Gutierrez reported that the departmental practices, beliefs and general cultures affected student performances and attitudes to mathematics and science.

Solomon (2007a) presents an analysis of 13-15 year old British pupils' accounts of learning and doing mathematics in a comprehensive school that sets[7] pupils for mathematics by ability groups. 18 girls and boys were involved in the study and they were interviewed on their relationships to mathematics in terms of the levels of access to the construction of mathematical meaning and their related identities of participation/ non-participation. Solomon reported that the top set students were engaged and knew not only the basic mathematics but also how to manipulate the mathematics they had learnt. This helped them develop 'participative identities', while the lower set students described their learning of mathematics as memorising facts and algorithms which resulted in them developing 'identities of marginalisation' (*ibid*:15).

As far as mathematics is concerned, identity of engagement (normative and core identity) is essential to students' beliefs about themselves as learners and as potential mathematicians (Boaler and Greeno, 2000; Maher, 2005) and it has vital gender, race and class components (Boaler, 2002; Gilborn and Mirza, 2000; Nasir and Saxe, 2003; Black, 2004) as presented in Section 2.6.

It is evident that the discourse and pedagogy experienced in mathematics classrooms, as shown in these studies, contributed to the construction of mathematics and the differential

[7] Setting is placing pupils into lower, middle, higher ability groups for the purpose of teaching a subject like mathematics.

identities developed by the pupils. However, the literature reviewed so far only looked at the construction of mathematics by learners of a school age. A follow-up study to examine how the discourses about mathematics experienced in schools might shape learning and sense of self at a later age is valuable. My investigation looked at how the construction of mathematics experienced at the early age of learners becomes essential in developing learners' beliefs and position at a later age.

McLeod (1992:579) suggested four categories of student beliefs in relation to mathematics:

1. Beliefs that mathematics is difficult or that it is based on rules that need to be learnt;
2. Beliefs learners have about themselves, which includes self confidence and attributions for success and failure in mathematics;
3. Beliefs about mathematics teaching and the type of support students expect from teachers;
4. Beliefs about the social context in which mathematics teaching occurs where factors outside school affect its learning.

Some empirical studies that support the categories of beliefs suggested by McLeod are reviewed below.

Zan (2000) studied the effectiveness of providing additional instructional support for 27 biology students at university level in Italy, who repeatedly failed the final examination of a compulsory module in mathematics. The study found out that in addition to other affective[8] factors, students' failure to pass the examination was not necessarily due to their lack of knowledge of the mathematics topics but the influence of 'loser beliefs' within

[8] Explanation of affective factors is given in Section 5.3, p.118

themselves. The study reported the instructional intervention in the shape of preparing the students for examination and confidence building exercises proved effective. Mason (2003) presented the result of a study involving 599 high school students who focused on their beliefs about mathematics and themselves. The beliefs of learners as mathematics being 'difficult and hard' were detrimental to their learning and achievement. The students positioned themselves as unable to 'do' mathematics, which contributed to their low performances. Singh, *et al.* (2002) examined the effects of constructs (motivation, attitude and academic engagement) on school students taken from a longitudinal study in the USA. The study showed that the motivational factors had an effect on their success in mathematics, and students who positioned themselves and showed positive attitudes about what they were learning achieved more than those students who positioned themselves with poor attitudes. Likewise, Mulat and Arcavi (2009) investigated the achievements of immigrant students in a technological university in Israel. The investigation identified the main contributing factors to their outstanding achievement in mathematics to be the beliefs of the students about the importance of mathematics, their determination and their effective learning and coping strategies. Parsons (2005) presented a result of an investigation of self-confidence in mathematics of first year students in the UK and reported that lower levels of previous achievement gave rise to lower confidence levels. A study carried out by Parsons, *et al.* (2009:65) also showed that students' confidence to have significant relations with performance both at pre- and university mathematics levels. The literature presented above suggests that the belief that the learners have about themselves in relation to mathematics impacts upon their learning and achievement.

The belief about mathematics and the position of learners of mathematics at university level are derived to some extent from the general predisposition to mathematics that learners have had at school level (Schoenfeld, 1992). However, Evans (2000) stated that students in higher education who are not mathematics majors[9] often have negative images, beliefs and attitudes towards mathematics. Sutherland and Dewhurst (1999) also reported that non-mathematics students often lack confidence and have anti-mathematics feelings; Croft and Ward (2001) indicate that some engineering students lack confidence in mathematics; while Parsons, *et al*. (2009) investigating the relationship between confidence and achievement indicated that better mathematically qualified engineering students were generally more confident and successful in mathematics. I suggest that when students elect a subject as their major subject they are likely to have their eyes on the future and have greater affiliation with the subject they study and construct their core identity (becoming a mathematician) around the subject. However if mathematics is not their major subject but they are obligated to do it, as Evans pointed out, the students may develop negative image of mathematics, less motivated to study and to be engaged with it. Crawford, *et al*. (1994) carried out an investigation to identify the concept of mathematics held by 300 first-year mathematics students and their approaches to studying mathematics. Results from the quantitative data identified the perception of the students about mathematics to be in terms of mathematics being a set of rules and procedures to be learnt by rote, and being a complex logical systems providing insights about the world. Crawford, *et al*. concluded that there was significant relationship between the conceptions (belief what mathematics is, etc.) of the students and their approaches on how to learn it. Solomon (2006) presents an outcome from interviews of 12 first-year undergraduate mathematics students' regarding their personal perceptions of mathematics and mathematics learning. The participants were all mathematics students and only two were mature students. From the interviews, Solomon identified beliefs about the nature of mathematics to be very

[9] i.e mathematics is not taken as the main subject.

similar to those observed by Schoenfeld (1992) which were discussed earlier; and in particular that the students tended towards perceptions of mathematics which assumed 'certainty, irrelevance, rule-boundedness and lack of creativity potential in pure mathematics' (Solomon, 2006: 383). That is, the emphasis was on 'speed and fixed ability' and the author reported that although the choice of opting to do mathematics could be associated with a strong and positive belief about learning mathematics, it was not evident in the belief of the first year mathematics students under her investigation. Solomon also stated that the students positioned themselves as outside of the 'mathematics community' (*ibid:* 384). This has implication and relevance in my research since the mature non-specialist students are by default obligated to do mathematics and thus more likely to be positioned outside of the 'mathematics community' and less motivated to be engaged with mathematics.

Solomon, *et al*. (2011) studied a group of undergraduate mathematics students regarding positions taken by women students. The study involved interviews and focus groups on 33 university students (12 first year and the remaining in their second and third years), of which only three were mature students; and questionnaires were completed by 130 second year students, of which only eleven were mature students and the students were drawn from three English universities. The study showed that the experience of tutor-student relationship was more positive for the male students than the female students; the attitude towards group work and asking questions in class was more positive for female students when compared with the male students. The authors concluded that the way the students position themselves in relation to mathematics had impacted on their learning. This impact arose from the relationships learners have with their tutors, their views on group work and the gendered roles in the learning of mathematics. The investigations presented above showed how positioning self in relation to mathematics impacted on learning mathematics.

These studies show the significance of learner's beliefs and positioning of self in the learning of mathematics. They indicate that students from diverse backgrounds found it hard to develop an interest or a motivation for learning mathematics. This problem was shown to be exacerbated, in particular, by mature non-specialist students (Zan, 2000) where the need to acquire mathematical skills may not be felt. The investigations also showed the role played by the discourses through which students of mathematics position themselves (Solomon, 2006). In the following section I review the relevant literature on the pedagogy practised in teaching mathematics at various levels.

2.5 The pedagogy used in teaching mathematics

The term pedagogy is to be used in reference to the methodology implemented to deliver a subject to a diversified group of learners. The delivery can be made, for example, by the traditional method (where learners are given by their teacher a list of mathematical rules and procedures that need to be learnt and remembered) or, as used in Boaler (1997), the 'reform/progressive' method (with teaching based on a discussion-oriented style where students are initiated/encouraged to contribute to problem solving).

According to Boaler (2002) there are also other factors that influence significantly the type of pedagogy chosen for implementation in a classroom. These could include, for instance, the organization of the school (for example, single-sex or mixed, independent or public); the extent of disposable resource available (books and other consumables); the staff members (their qualifications, gender dominance); the type of students (dominating gender, age, class, ethnicity); methods of assessment being implemented; curriculum followed; and anything else that is believed to enhance learning in general. In addition, as Boaler points out, ‘different pedagogies are not just vehicles for more or less knowledge, they shape the nature of the knowledge produced and define the identities students develop as mathematics learners through the practices in which they engage’(*ibid*:132). Studies from Becker (1995) and Banks (1993) indicate evidence that knowledge presented in an abstract, decontextualised way is more alienating for girls than boys, and for non-Western than Western students, and that pedagogy with an holistic approach benefits female students. Likewise, Boaler (2002:151) points out the reasons for girls’ disaffection and underachievement is ‘related to pace, pressure, closed approaches that did not allow them to think in a competitive environment’.

Solomon, *et al*. (2010) investigated the experiences of second and third year students learning mathematics at university. The investigation was based on focus group interviews of 21 mathematics and statistics students and 38 second-year students who completed a questionnaire covering various aspects of their experiences of learning mathematics at school and university. It was reported that, as part of the pedagogy, providing tutoring space facilitated for student learning-communities to emerge. That is, although the learners found the learning of mathematics significantly difficult they were able to develop group-learning strategies; thus learning mathematics became a social experience. In line with the discourse of learning mathematics by doing exercises, the importance of open access space to help them work together, share knowledge and the techniques of tackling mathematical problems become essential. Croft and Ward (2001) identify an environment for learning engineering mathematics that includes lecture and tutorials where students meet tutors to ask questions, learning support centre where one-to-one help is available and the use of modern technology. Hoyles (2010) and Lawson (2010) emphasise that universities must have in place as part of pedagogy appropriate support mechanisms, such as drop-in centres where students making the transition from school to university and wishing to study quantitative subjects could be supported and encouraged to develop their confidence. In addition, as suggested by Fayowski and MacMillan (2008), students should be given an opportunity to develop personal initiative and responsibility to acquire 'problem-posing-and- solving skills' that enables them to collaborate and work with others. Learners of mathematics have been exposed to various pedagogies. More specifically, Smith (2002:126-7) gives four essential conditions for learning mathematics. They are: mathematics itself must be interesting and comprehensible; there must be no fear of mathematics; no negative construction of mathematics; and ample time allowed for learning it.

In the following section I review the relevant literature on the constructed identities of the learner and their impact on the learning of mathematics.

2.6 Social class, gender, ethnicity and mathematics

The debate on unpicking the possible factors for the difficulties that pupils face in learning mathematics focuses predominantly on social class, ethnicity and gender of the learners and the pedagogy in general. In the UK, the roles played by the social class, gender and ethnicity and their combinations in the attainment of students have been given a wide coverage. My investigation has benefited from looking at the impact of social class; ethnicity and gender on the learning of mathematics observed in school students as they are also in operation at university level (Solomon, *et al*., 2011).

2.6.1 The impact of social class on learning

i. Social and cultural capital

The additional support (or lack of it) given to learners outside of schools and other teaching institutes contributes greatly to the learners' successes (Noyes, 2004). However, additional support made available to learners is dependent, among other things, on the social class of the learner's parents/ carers (Archer, 2010). As pointed out in Section 2.2 above, research suggests that there is a relationship between the extent of social bonds within families and communities and children's achievement at school. The 'home background' (Francis and Skelton, 2005:70) otherwise taken to be similar to what Bourdieu refers to 'social capital and cultural capital' is strongly associated with pupils' academic performance. In light of Bourdieu's theory of social and cultural capital, children from upper- or middle-class families are seen to be advantaged and do better academically than those from poor or socially-disadvantaged families. This is because their possession of knowledge and skills (cultural capital) are rewarded and considered valuable to academic achievement in the educational field (Bourdieu, 1984; 1997; Bourdieu and Wacquant, 1992). Wiliam and Bartholomew (2004), after analyzing the GCSE mathematics achievement of a cohort of students, confirm that the social background of pupils contributed to the disparity in achievements, where students from a middle-class background outperformed students from a working-class background.

ii. Socio-economic status

In the UK, free school meals (FSM) eligibility of pupils is widely used as a proxy for socio-economic status in educational research (Hobbs and Vignoles, 2007). Data from DfE (2012) show that pupils known to be eligible for FSM performed less well as a group in GCSE subjects than all other pupils; however the attainment gap in all subjects has narrowed by 8.7 percentage points from 27.1 in 2006/07 to 18.4 in 2010/11; while the gap is 23.3 percentage points in mathematics. The report from DfE (2012) points out that the attainment gap for the White British boys eligible for FSM has improved over the last five years; and the gap has also narrowed for the Black Caribbean boys since 2006/07. Francis and Skelton (2005), looking at pupils who take FSM, were able to assess the effect of socio-economic factors on their achievement. Their findings show that the performances of pupils receiving FSM are lower than those not receiving FSM, indicating that socially- and economically-deprived pupils perform less well in examinations (*ibid*:59-60). Kingdon and Cassen (2010) studied ethnic dimension of low achievement in English schools. Using the National Pupil Database for 2003 and KS4 (GCSE level), examination results reported that economic disadvantage is a much bigger risk factor for low achievement for White pupils than for most other ethnicities. This could be due to the de-motivation that might have resulted from the FSM status, which means different things for White British students. Mensah and Kiernan (2010) carried out similar studies in the USA and Canada and reported that there is a strong correlation between families' socio-economic status (SES) [10] and boys' educational attainment compared with girls'. The attainment of boys is more affected by their families' SES than the girls'. Similarly, the authors looked at a large-scale longitudinal survey of children in the UK and confirmed that the effects of disadvantage appeared stronger for boys than for girls in their development in mathematics. The literature quoted above indicates the impact of both social and cultural capitals and the socio-economic status of the family on the achievement of school students. My investigation explored the experiences of the mature students with regards to the impact of social and cultural capitals made available to them on their learning of mathematics at university level.

[10] SES can indicate the position that an individual or family occupies with reference, for example, income, wealth, etc.

2.6.2 The impact of ethnicity on school attainment

The literature reviewed concentrates on the impact of ethnicity on academic achievement in general; and the review identified the following two themes:

i. Clusters of ethnic groups and their academic achievements

According to the data from DfE (2012) the proportion of pupils achieving passes in five GCSE subjects including English and mathematics continues to vary between different ethnic groups. For example, the data reveals that:

- pupils from any white background achieved broadly the same as in the national level (58% and 58.2% respectively) and this gap has remained constant since 2009/10;
- pupils from any black background achieved below the national level (54.3% and 58.2% respectively) and this gap has narrowed since 2006/07;
- pupils from Asian background performed above the national level (61.8% and 58.2% respectively) and the gap has widened since 2006/07;
- pupils from Chinese background performed above the national level (78.6% and 58.2% respectively) and the gap has increased since 2006/07.

Individual researchers confirm, as shown below, the results implied from the DfE (2012) report. Drawing on a large amount of quantitative data, Demack, *et al.* (2000) analysed the attainment variations of five cohorts of state school leavers between 1988 and 1995 comprising over 80,000 16-year-old students from England and Wales. The analysis showed two distinct attainment clusters of ethnic groups; Indian, Chinese and White students in the higher cluster, while Black, Pakistani and Bangladeshi students in the lower cluster. Nevertheless, some of the ethnic groups mentioned in this undertaking are homogenised. For example, no distinction is made between African and Caribbean black.

Demack, *et al*. (2000:138) confirmed that educational attainment is continually affected by gender, ethnicity and social class as reported in the following quote:

> Gender, ethnicity and social class are three factors which continue to have an effect on educational attainment, on the transition from school to work and on the later life chances of all children in England and Wales.

In addition, Gillborn and Mirza, (2000), distinguishing the makeup of each ethnic groups with the aim of establishing the relative significance of ethnicity, social class and gender, reviewed the evidence available concerning education inequalities in all the schools within the London Educational Authorities. Gillborn and Mirza, in agreement with Demack, *et al.* (2000), concluded that African-Caribbean, Pakistani and Bangladeshi pupils are disadvantaged; social class and gender differences are also associated with differences in attainment where significant ethnic inequalities in attainment remain clear. According to Gillborn and Mirza (2000), the causes for this inequality include limited access to equal opportunities (social and economic) these groups of pupils were given. Crozier (2005), investigating the parents of black pupils on their views regarding the underachievement of their children, reported how a pattern of cumulative negative experiences, resulting from low teacher expectations and negative stereotyping of young black people, contributed to their underachievement. Crozier argued that the institutional racism that exists in the education system should be addressed in order to improve the achievement of Black-Caribbean children. Haynes, *et al.* (2006) used quantitative and qualitative data to identify the barriers to achievement for minority ethnic pupils in English schools. Haynes, *et al.* found that the combination of low socio-economic position, the low expectations of their teachers about them and the influence of peer group pressure produced major obstacles to the pupils' achievement.

ii. Ethnicity and mathematics learning

Archer and Francis (2007) carried out a comparative study of the achievement of the different ethnic groups starting from Key Stage Level 1 through GCSE. Archer and Francis identified that, in mathematics, the Chinese pupils, as a group, performed best, followed by Indian and White pupils; while Black Caribbean, Black African, Pakistani and Bangladeshi pupils performed below the first cluster mentioned above. Archer and Francis also pointed out that the Travellers of Irish Heritage and Gipsy/Roma pupils performed very badly, while the girls from all ethnic groups except Gypsy/Roma achieved better GCSE grades than boys. After the authors noted the emerging pattern in the comparative achievement across the various ethnic groups, they asked the British-Chinese pupils to list, in order of preference, their favourite subjects. They reported that mathematics is at the top of the boys' and girls' choices (*ibid*: 93). The explanation given to this outcome is related to the reflection of the discourse in mathematics that it is culturally positioned as a very important subject (*ibid*: 94; Cockcroft, 1982).

It is believed, too, that the cultural background of the learners could play a significant role in the learning of mathematics at university level (Solomon, *et al*., 2011). Studies carried out in the USA, for example, Ladson-Billings (1997) reported that African-American students continue to perform poorly in school mathematics. According to Secada (1992) the mathematics achievement gap between the White- and the African-American appears to be narrowing only on low-level mathematics and basic skills.

The studies presented above show the impact of ethnicity on the academic achievement and learning of mathematics of school pupils. I argue that the findings have impact on learning in the later ages of their learning life.

2.6.3 The impact of gender on learning mathematics

In order to understand the issue of gender and mathematics in the UK, I found it necessary to first highlight the changing pattern of achievements in mathematics of school boys and girls. In the 1970s mathematics was considered to be a masculine subject and girls opted for the more traditionally 'feminine' subjects (Walkerdine, 1998). The concern expressed in 1976 by the then Prime Minister James Callaghan about the high proportion of girls abandoning science before leaving school initiated various measures to address the imbalance in mathematics and science (Smart,1996). During this period the girls achieved lower than the boys. Francis (2000a), drawing on the theory of social constructivism, described the gender and achievement issue of the 1970s and 1980s as an era where gender inequalities in the classroom was clearly seen; girls were marginalized and belittled; and systematically discriminated by their classmates, teachers and the education system. Girls avoided the so-called 'hard' sciences and when they were persuaded to take them the girls scored lower than the boys (Spender, 1982). It is well documented, (for example, Spender, 1982; Terry and Terry, 1998) that a number of initiatives were taken by governments and women's movements to bolster girls' achievement in mathematics and science; and the initiatives began to bear fruit in the late 1980s where a steady but small improvement in performance in A-levels mathematics of the girls' was reported (Smart, 1996). Data from DfE (2012) also show that the gap between the proportion of girls and boys achieving five or more passes (A* - C) in GCSE English and mathematics is between 8.2 percentage point in 2006/07 to 7.3 percentage point in 2010/11 in favour of girls; the gap remains relatively stable and it is narrowing. The provisional data on the attainment gap for 2011/12 between girls and boys in GCE AS level mathematics show a gap of 3.7 percentage points in favour of girls (DfE, 2012). The report also confirms a similar pattern of higher proportion of girls than boys achieving grades A-E in A-level mathematics throughout the past decade. The literature review below focused on the theme of different learning styles for boys and girls; the gender inequality and how the learners construct mathematics and position themselves when learning mathematics.

i. Different learning styles

The assumption that boys and girls are ‘naturally different’ supports the idea that they will also have different approaches to learning. Hence the gender gap in achievement has been accounted for by the differences in the learning styles of boys and girls (Coffield, *et al*., 2004). For example, Noble and Bradford (2000) examined the issue of raising achievement in mathematics and science. They point out that in the imagination of many boys, science appears to offer them a chance to work with other pupils and experiment with things that would excite them. The main attraction of mathematics for the boys is the short-term challenges it gives them, the very little descriptive writing it requires and the chance that it creates for them to use gadgets such as calculators and other mathematical tools. Various researches, for example, Gurian (2002), Francis and Skelton (2005), show that boys and girls have different learning styles and girls not only try to understand and learn mathematics but they also try to relate it to their experiences.

Boaler (1997) studied two schools to contrast the effect of pedagogy on achievement in mathematics. The results of the study showed that the girls in the group in which a ‘traditional’ method was used demonstrated anxiety and disaffection and they underachieved in mathematics when compared with the boys; while for the group where the ‘reform’ method was used, anxiety and underachievement were avoided amongst the girls. The findings of the studies presented above show that pupils have preferred ways of learning. Consequently I have investigated the role of learning styles of the mature students covered in my study, asking, for example whether the pedagogies at the university accommodate the different learning styles of the mature non-specialist students and whether the learning provisions made available within and outside the university contribute to their learning, and how.

ii. Gender inequality

Girls are currently outperforming boys in many secondary school examinations (DfE, 2012). Although the gender gap in achievement is narrowing for selected subjects, what is persistent is the gender difference in participation rates in mathematics and the sciences after the age of compulsory education in Britain (Governmental Statistical Service, 2002; Orton, 2004; DfE, 2012). The male dominance in mathematics-related jobs and in studying mathematics at higher levels, including undergraduate and postgraduate studies, is also found in the majority of countries (Blattel-Mink, 2002; Mendick, 2006). Nevertheless recent report (LMS, 2013) shows that the proportion of female graduates (First Degree) has risen from 40% in 2004/05 to 44% in 2010/11. I looked at data collected from mature students to explore the association[11] of gender to the learning of a mathematics module at university level.

iii. Construction of mathematics

The image of mathematics as being masculine and the position of women studying mathematics are different today from that of the past decades, as the following study shows. Francis (2000b) studied the construction of gender, school subjects and ability of secondary school students. The study involved classroom observation and semi-structured interviews with 50 girls and 50 boys selected at random from three different mixed-sex schools in Greater London. The participants were 14 – 16 years old who were at middle or top set mathematics classes. The interviews covered a range of topics concerning gender

[11] See Chapter Seven for a quantitative analysis of the belief of the association of mathematics with gender.

and education. The participants of the study were asked to list their favourite and least favourite subjects and their views on the ability of male and female students at different subjects. Francis found that the female and male students did not consider mathematics to be a masculine subject; English and mathematics were ranked to be their first and second favourite subjects, respectively, with more female students listing mathematics as their favourite subject than the male students. As regards to the ability of the two genders, the students believed that there was no difference in ability between female and male students in all school subjects.

In contrast, a study exploring gendered patterns of participation in Further Mathematics A-level on a group of secondary school students was revealing. Mendick (2005) looked at why more boys than girls choose to study mathematics post-secondary school requirements of A-levels. She interviewed and observed 42 mathematics students aged between 16 and 19 and one mature student. The participants were interviewed about their experiences of learning mathematics, and drawing on theory of psychoanalysis[12], interviews from three male and two female further mathematics students were analyzed. Mendick explored and questioned the socio-cultural context that made the interviewed three male students position themselves 'good at maths', while the two female students deny they were thought of by their peers as being 'mathematically able'. Mendick pointed out that rationality is associated with gender and the discourses socially construct 'mathematical ability' as natural, individual and masculine (*ibid*: 204). This socio-cultural construction of gender and mathematics makes it more difficult for girls and women to be identified as 'good at maths'. Drawing on feminist theory, Mendick concluded that the participants perceive mathematics as 'masculine' and that it is more difficult for girls and women to 'feel

[12] A psychoanalytic approach enables us to see how discourses create anxieties within oneself about mathematics.

talented at, and comfortable with, mathematics so to choose it and to do well at it'(*ibid*: 217). In addition, it could be said that the gender imbalance of the class made the girls a minority. This environment might have put the female students into a position of not accepting to being thought by their peers as 'mathematically able' and feel to lack confidence in their ability (Hyde, *et al*., 1990) and it is likely that they have positioned themselves as having 'less right' to be considered as 'mathematically able' (Solomon, 2007a). It appeared that the girls in the study preferred to remain invisible. This phenomenon of remaining invisible and becoming successful by a group of women students doing mathematics at an undergraduate level has been studied by Rodd and Bartholomew, as reviewed below.

iv. Self-positioning

Rodd and Bartholomew (2006) studied the experiences of young women students in undergraduate mathematics degree programmes at two traditional universities in England. The study drew on data collected from a longitudinal project investigating students' experiences of undergraduate mathematics. The women in the cohort were 18/19 years old at the beginning of their course and the main aim of the study was to understand better the reasons why students studying mathematics at the undergraduate level have different attitudes to the subject. Data were collected from a questionnaire, interviews and observations; and data from five women participating in narrative style interviews were analyzed using interpretive feminist perspective. Rodd and Bartholomew reported the actions and motivations of the women who participated in the study and how the women negotiated their way to remain invisible and special and succeed in a subject considered to be masculine. However, recent study by Solomon *et al*. (2010) has suggested that collective physical spaces made available for undergraduate mathematics students had given the opportunity to women mathematics students to reflect and critically scrutinize the dominant discourse of mathematics and the discourse of ability and learning. Solomon (2012) points out that the physical space made available to the students provided an opportunity for the development of 'new spaces for being both mathematician and female'. Solomon by focusing on the narratives of two successful mathematics students discussed the scope and impact of reflexivity on how '(self-) positioning of women within the figured world of mathematics both as mathematical and female' was constructed and the nature of resistance to discourses which construct mathematics as a masculine domain. Solomon concluded that 'there is no easy link to be made between reflexive accounts of gender and ability and a change in the (self-) positioning of women in mathematics – despite their reflexivity, mathematics is still portrayed as gendered, as a masculine field' (*ibid*: 181). The findings of this study has application in my investigation of the discourses that position learners in relation to the construction of gender and mathematics and the effort made by the mature students to learn mathematics as an ancillary subject. Nonetheless, as pointed out by Walkerdine (1998:23) gender differences in mathematics achievement can be explained by the attitudes of the 'socializing agents' including teachers, parents, the media, school authorities, etc. The key point is that talents of learners should not be restricted due to the discursive construction of mathematics. The review shows the difficulties faced by group of learners of mathematics as a main subject both at school and HE levels. I have investigated how the discursive construction of mathematics that emerged from the literature review links with the difficulties those mature non-specialist students in relation to their identities face when learning mathematics as an ancillary subject.

2.7 Summary

The literature review highlighted some of the discourses that position mathematics as a subject by those who design the curriculum and the various positions and identities assumed by the learners of mathematics at school and HE levels. It seems evident that a study that focuses on mature non-specialist students to contribute to gaps in knowledge on the impact of positioning self within the discourse of mathematics is essential. The literature review has helped me to raise research questions regarding students covered in my investigation who were doing mathematics as an ancillary subject.

The literature review pointed out the contradictory positions within discourse given to mathematics as a utility subject or a discipline by itself (Section 2.3). This position implied the need to investigate how such positioning of mathematics affect the views of the mature non-specialist students when learning mathematics. Do the mature non-specialist students view an inclusion of a mathematics module in their courses as an imposition by the program-planners or a module that offered them additional and useful skills; and how, do the students covered in my case study position themselves with regards to mathematics?

As pointed out in the reviewed literature difficulties in the learning of mathematics and a negative attitude/belief towards it is widespread among students (Section 2.4). This led me to ask: how do the mature non-specialist students construct mathematics – a subject hard to understand, rigid, or a subject with which they could positively identify themselves; has their construction of mathematics been influenced by their previous experiences of learning mathematics?

The literature review illustrated the different perceptions of learning and the significant role that the pedagogy could play in the learning of mathematics (Section 2.5). This led me to consider how the students covered in my case study perceived the way mathematics was taught at university level. Is there any preference of pedagogy for the various groups of students based on their gender, ethnicity and social class; and how they position themselves and or positioned by others as learners of mathematics at this level?

The literature review highlighted the debate on the impact of the social characteristics of the learners on their learning of mathematics (Section 2.6). I found the debate worthy of further exploration and investigated the views of the mature non-specialist students covered in my case study on statements like ‘mathematics is gendered’ and ‘some ethnic groups are better at mathematics than others’.

The following chapter discusses the ways in which the questions emanated from the literature review are addressed through biographical data collected from the mature non-/specialist students.

CHAPTER THREE

Research Design

3.1 Introduction

This research set out to examine the experiences of mature non-specialist students when learning mathematics. For an effective and efficient study it was necessary to identify a research design that could enable the collection and analyses of relevant data within a poststructuralist theoretical framework.

Creswell (2009:3) defines research designs as overall ‘plans and the procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis’. The choice of a research design mainly depends on the purpose and belief of the researcher about his/her research. The chosen design should be able to provide adequate information to address the main research question (Blaikie, 2000; de Vaus, 2001; Mason, 2002; Creswell, 2003). Accordingly, my choice of research design was guided by the main research question, ‘Why do some mature non-specialist undergraduate first year students taking mathematics as an ancillary subject find mathematics challenging and fail to pass it?’ The nature of the research question, with subsequent probing questions, generated both qualitative and quantitative sets of data.

Robson (2011) describes three types of research design, fixed, flexible and a combination of these two. The fixed type of design focuses on quantitative data while the flexible design deals with qualitative data. My investigation involved both quantitative and qualitative data and hence the combined research design, also known as the Mixed Methods Design (Creswell and Plano Clark, 2007) was found to be the design appropriate for implementation as justified below. The instruments used and the procedures followed in the data collection and the methods of analyses employed in my investigation are described later in the chapter.

3.2 My epistemological position and justification to use Mixed Methods Design

Throughout my thesis, to address the research question, I have utilised the experiences of learning of mathematics by non-/specialist mathematics first year undergraduate students doing mathematics. My analyses show that based on their experiences some students position themselves within a discourse or positioned by a discourse in a particular way. As pointed out in Section 2.2, discourses, in this case discourses about mathematics, position people or people position themselves within a discourse; and their identities constructed through discourse (Foucault, 1980). According to Davies (1993: 13):

> Poststructuralist theory argues that people are not socialised into the social world, but they go through a process of subjectification.[..] In poststructuralist theory the focus is on the way each person actively takes up the discourses through which they and others speak/write the world into existence as it were their own.

Poststructuralist theory enables me to understand how the participants construct their identities and positions as regards to mathematics and the learning of mathematics. Taking poststructuralist approach when doing research means to see 'discourse as operating within regimes of truth not because of their power to describe reality but because of their power to produce it' (Mendick, 2006:18). In this theoretical framework, truth is understood as constructed. Post-structuralism offers me very different ways of looking at and beyond the obvious and taken for granted. Many research inquiries involve paradigms[13] using data of both objective nature (where researchers and participants are independent and the data set is value[14] free) and subjective nature (where the researcher and the participants interact and

[13] Paradigm is an overall conceptual framework for how to look at reality (Silverman, 2000: 436).
[14] The term value refers to the influence of the researcher on the results of the research or on the participants.

work together to construct social realities; and the data becomes value laden). Mertens (2003:141) argues that there are situations where a researcher requires a highly interactive relationship (e.g. teacher-researcher and student being researched) to answer a research question thoroughly; or the research may not need interaction with participants (e.g. experimental research to test hypotheses using a quantitative method). As pointed out earlier, my investigation required the gathering of biographical data through interviews which involves interacting with participants; and a survey in which a minimum interaction with participants completing the questionnaire is expected. I position myself as pragmatic and used both paradigms (objective and subjective). The justification for this position is my focus on finding ways that help me unfold the perceived factors that affect the learning of mathematics by mature non-specialist students and my belief that Mixed Methods Design best facilitates in meeting my research objective.

The following reasons justify the use of Mixed Methods Design in my research:

- The research question and the questions that generate the data consist of both exploratory (why/how) and confirmatory (what) questions;
- The sampling techniques employed are purposive (for the interviews) and convenient/systematic sampling (for the questionnaire);
- The data collection strategies were interviews (one-to-one and focus groups) and questionnaire (survey);
- The data analyses methods used thematic (for the qualitative data) and statistical analyses (for the quantitative data) in the form of Factor, GLM and Logistic Regression[15] Analyses.

[15] These are explained in detail in Appendix 4.

According to Creswell and Plano Clark (2007: 552) 'Mixed Method Design is a procedure for collecting, analysing, and mixing both quantitative and qualitative research methods in a study as deemed appropriate'. The purpose of mixing the two methods, qualitative and quantitative, is to gain a better understanding of the researched and of the research problem than would be achieved by just using one of the methods, because diverse types of data best provide an understanding of a research problem (Creswell, 2009) and provide cross-data validity checks (Patton, 2002:248). The social experiences of people and their lived realities are not single dimensional.

Of the type of mixed research designs available, I used the sequential exploratory Mixed Methods Design. This involved collecting relevant qualitative data first and then collecting quantitative data that will shed additional light on the results found in the qualitative data. The need for using the mixed methods in my research arose from my pragmatic stand of wishing to address satisfactorily the main research question and focussed on the requirements of the inquiry being investigated (Patton, 2002). The theoretical framework for Mixed Methods Design could be thought as one of discovery or conforming (Morse, *et al*., 2006). According to Teddlie and Tashakkori (2003), the mixed research method has the advantage that it can answer research questions where other methodologies cannot; it provides better and stronger inferences and the opportunity for presenting a greater diversity of views. The use of both approaches together allowed me to compare results in a complementary way, reinforcing each other (Gorard and Taylor, 2004; Morse and Niehaus, 2009). Apparent discrepancies between quantitative and qualitative results can be explained by using mixed research methods; since data from a questionnaire give a general picture while qualitative data give a richer understanding. The combination of the two approaches produces understanding with deep insight over a large population. This can make it a very cost effective research strategy (Teddlie and Tashakkori, 2009).

On the other hand, according to Teddlie and Tashakkori (2009: 325-328) Mixed Methods Research is exposed to some challenges. I have examined some of those that have direct implications for my research. These are:

- The stage at which combining the two approaches (qualitative and quantitative) takes place - does it take at the formulation of the research question or at the data analysis level or sampling or at the stage of interpreting results?
- How to formulate the research question - should there be only one research question or separate questions for the qualitative and quantitative approaches?
- How inferences are made - should inference from the analyses be made only on the basis of the qualitative or the quantitative analysis?
- How to explain diverse results (if it occurs) from the qualitative and quantitative analyses?
- The danger of using the same individual(s) in the various sampling subgroups.

I reflected on these challenges and the measures I have taken in my last chapter; in this investigation I focused on what works in bringing out the possible answer(s) regarding the research question under my investigation. As Punch (2005:290) points out:

> Quantitative research brings the strength of conceptualizing variables, profiling dimensions, tracing trends and relationships, formalizing comparisons and using large and perhaps representatives samples; while qualitative research brings the strengths of sensitivity to meaning and to context, local groundedness, the in-depth study of smaller samples, and great methodological flexibility which enhances the ability to study process and change.

The full analysis and interpretation of the results using the methodology described above are presented in the Data Analyses chapters. However there are ethical issues that could arise, both at the data collection phase and analysis and interpretation stage as presented in Section 3.5.

3.3 Research methods

Research methods are the means or instruments by which the data from the participants under study are collected (Cohen, *et al.*, 2003). The types of data suitable for my investigation were personal accounts resulting from the experiences of the participants when previously learning mathematics; and also survey data. This is because the learning experiences could be best related as narratives by the mature students themselves. I identified the following data-collecting instruments as appropriate for collecting data that could help address the main research question:

(1) In-depth, one-to-one interview – this method of data collection provided me with the opportunity of listening to discourses about mathematics and obtaining detailed and full answers about the participant's experiences of learning mathematics. I was able to observe the facial expressions and body language to be aware of the feelings of each participant that helped me better understand their perceptions, values and assumptions about mathematics learning. However this method of data collection has its limitations – it is open to interviewer bias; difficult to generalise information collected to a large scale as the questions are not standardised; and poses difficulty in arranging interviews, making it time consuming (Robson, 2011: 280).

(2) Semi-structured focus group interview – this method enabled me to collect information from a group of students about their perceptions, values and assumptions about mathematics. It is a cheap and quick method of collecting a broad range of views on the research question. However conducting focus group interviews requires skills of gauging

the group dynamics as there could be one/two individual(s) who dominate; thus undermining other participants; some participants might feel embarrassed to talk; data might not be as good as the data obtained from the one-to-one interview; and the sample would not be representative, as the participants are volunteers (*ibid:* 293).

(3) Purposely constructed questionnaire – this method of obtaining information proved to be useful as I was able to collect data from a large subgroup of first year undergraduate students in a short time. It is not researcher-dependent; that is, the questionnaire can be distributed by any member of staff. Information obtained from a questionnaire can easily be quantified using a statistical package; and the result from such analysis can be used to compare with results from other research. The limitations of this method include the misinterpretation of the questions by the respondents, some respondents might not be willing to answer some of the questions truthfully, and the response rate could be low (*ibid*: 260).

The data collected by these methods together provided a clearer picture of the factors that these mature students believed affected their learning of mathematics. The main reason for having both one-to-one and focus group interviews is that the one-to-one interviews provided a platform to listen to discourses and investigate the experiences that the mature students doing mathematics had when learning the subject; while focus groups generally better suited to eliciting detailed contextualised histories and the individualized accounts we are seeking (Barbour, 2007: 42) allowing exchanges of ideas about new concepts to emerge (Morgan, 1988). These two methods of collecting data not only fitted my epistemological position (Section 3.2) but they are established methods of collecting data within poststructuralist theoretical framework (Evans, 2000). When investigating the data collected through the interviews, drawing on poststructuralist framework enabled me to understand the discourses that brought about the constructed truths by the mature students about their learning of mathematics.

(4) Sampling procedure

The sampling technique most appropriate for collecting qualitative data for my investigation was purposive sampling. The justification for using purposive sampling is a probabilistic sampling strategy approach is not necessary, as the focus of the study was to choose cases that were relevant to the investigation and reflect the diversity that could exist in the sample. Further, purposive sampling technique generates data which would probably not be accessible using other techniques, such as questionnaires. This technique allows the identification and inclusion of potential members of the interview groups. The criteria for the selection of the required number of students for my investigation were based on:

- *Age*: To include only mature students (age 21 or more)
- *Gender*: Equal number of male and female students (if possible)
- *Ethnicity*: White and non-white students
- *Status*: Home and overseas students
- *Field of study*: Business, Biomedical Science and Mathematics students.

Drawing on the themes obtained from the partial analyses of the interviews, a questionnaire was constructed and distributed to first year undergraduate students[16] covered in my study. Questionnaires are normally used when the investigation requires responses from a large number of respondents. The information obtained from this not only helped me examine the reasons for particular responses in the interviews, but also revealed the constructed views on the learning of mathematics held by the majority of first year

[16] The questionnaire was handed out to the first 250 students who were available and agreed to voluntarily take part in the investigation. This sample in a way can be assumed to be 'systematic'.

students who took part in the study. In addition, as pointed out by Evans (2000:6), questionnaires, together with the interviews, provide an ‘appropriate methodology’. Having introduced the data collection instruments, the next step was to actually gather the data.

3.4 Data collection

The following three questions structured the way in which the data were collected.

- What are the perceived factors that affect the learning of mathematics at the first year level?
- Do mature non-specialist students feel that the delivery of mathematics modules meets their needs, learning styles and preferences?
- How are the accounts of the learners related to their experiences of learning mathematics modules at university level?

I proceeded to select from the two fields of study two groups of first year undergraduate, specialist and non-specialist maths students, who had taken Introduction to Data Analysis (MA) or Quantitative Methods (QM) module as a core module, prior to the start of my investigation. The inclusion of specialist mathematics students in all the samples (one-to-one, focus group and survey) was in order to compare their views with the non-specialist students’. Accordingly, the first group of ten mature students (seven non-specialist and three specialist mathematics students), was chosen from the 2008/09 entry of students and used for one-to-one in-depth interviews to gain an understanding of the discourses in play and the experiences of the participants when learning mathematics. The details of how this group of students was chosen are given below, and it should be noted that the ten mature students had started their second year by the time my investigation started. This was an advantage for my investigation, since the students at this stage had completed the two modules with me. They could reflect on their first year and articulate their responses by relating their experiences of learning mathematics to the learning environment they were confronted with as first year students.

During these modules, many students would see me on a one-to-one basis. These meetings gave me an idea of the performance of many of the students. A week before the end of the teaching in the second semester, at both campuses, I asked for volunteers to participate in my investigation. I deliberately made sure that some of the students that I knew from the one-to-one meetings and had accounts that would be relevant to my investigation were included in the sample. There were not many volunteers for the individual one-to-one in-depth interview group, but I managed to secure an agreement from ten volunteers (equal numbers of female and male students). An invitation letter explaining the interviews and a consent form were given to each participant (Appendix 1, p.210). I address the ethical issues related to my knowledge of the students later in the chapter.

Following the in-depth interviews and noting views that were emerging, I subsequently carried out semi-structured focus group interviews that focus on these emerging themes. To this effect, I decided (based on the time I could afford for the research) to recruit a second batch of ten mature students from the 2009/10 entry doing the MA or QM modules in the autumn semester, as members of two focus groups, A and B; five participants at each campus. Unlike the one-to-one interview there were two more students than anticipated who volunteered to take part in the study; thus the total number of participants increased to 12, of which nine were non-specialist and three specialist mathematics students. The details of how the members of the two focus groups were selected are given below.

The students in the investigation were studying Biomedical, Business and Mathematics courses. The students following Biomedical and Business courses (72%) were non-specialist while 28% were specialist mathematics students. I planned to select a minimum of ten students from the two courses (non-specialist and specialist) and with this in mind; I invited volunteer students at both campuses to take part in my investigation. After two weeks, 32 students had registered to take part in the interviews. Subsequently, 12 students out of the 32 made themselves available for the focus group interviews (instead of the planned ten). The makeup of the two focus groups were seven volunteers in group A (four female and three male) and five volunteers in focus group B[17] (one female and four male). It is considered an advantage if the members of the focus groups feel comfortable to express their views, know with each other and have something in common to conduct a frank exchange of views (Robson, 2011:295). This would have been possible if, at least, the members were chosen from a subgroup having the same background. Since the focus groups in my study were formed from volunteer students doing different courses it was not possible to achieve such homogeneous groups. Ideally, I should have three focus groups, one focus group from each of the Biomedical, Business and Mathematics groups, instead of the two I had. The reasons for having two focus groups were purely for convenience, as it seemed unlikely that it would be possible to bring all the participants from the two campuses together under one roof at one time and the limited amount of time available to me to carry out all the interviews.

These procedures enabled me to get a total of 22 mature, 16 non-specialists and six specialist students, of which ten were female and 12 male who voluntarily took part in the in-depth and focus group interviews. The profile of the participants is given in Table 3.1

[17] Note that members of focus group A are specialists and non-specialists while that of focus group B are all non-specialists (see Table 3.1 for details).

(p.59). Both semi-structured interviews were conducted on the university campuses. With the consent of the participants, and according to the ethical commitments stipulated (see copy of ethical statement, Appendix 1, p.210), all interviews were audio recorded, transcribed and stored safely for use in their transcription.

To further understand the responses to the interview questions, it was felt necessary to collect additional data from a larger number of first year undergraduate students who had done at least one MA/QM module in their first year. So a questionnaire (see Appendix 3, p.218) was constructed and distributed to the first year undergraduate non-/specialist students at the two campuses. My colleagues and I distributed 250 questionnaires in April/May, 2010. The students were asked to complete the questionnaire individually while on campus during seminars, workshops or drop-in maths sessions. After a two-week persistent follow up of the students I was able to elicit 240 responses (96%). Examination of these returns revealed that 30 questionnaires were less than 10% completed and so had to be discarded. The responses of the remaining 210 students (84% of the total distributed) were coded and made ready for a quantitative analysis. The breakdown of the makeup of the participants/respondents is summarized in Figure 3.2 (p.68). The detailed descriptions of the data collection instruments are provided on page 60.

Table 3.1: Profile of participants of the in-depth and focus groups interviews

Student ID	Pseudo-nym	Gender	Self identified ethnic origin	Course	Interview
1	Carole	Female	White (British)	Biomedical (Non-Specialist)	In-depth one to one
2	Ed	Male	Black (Nigerian)	Mathematics (Specialist)	
3	Elsa	Female	Black (Ghanaian)	Biomedical (Non-Specialist)	
4	Faith	Female	Asian (Bangladeshi)	Business (Non-Specialist)	
5	Mario	Male	White (Greek)	Mathematics (Specialist)	
6	Marr	Male	White (Australian)	Biomedical(Non-Specialist)	
7	Martha	Female	White (Dutch)	Biomedical (Non-Specialist	
8	Maya	Female	Asian (Bangladeshi)	Business (Non-Specialist)	
9	Rao	Male	White (British)	Mathematics (Specialist)	
10	Simon	Male	Black (Nigerian)	Business (Non-Specialist)	
11	Alan	Male	Black (Nigerian)	Mathematics (Specialist)	Focus Group A
12	Donald	Male	White (British)	Biomedical (Non-Specialist)	
13	Ellen	Female	White (British)	Biomedical (Non-Specialist)	
14	Fiona	Female	White (British)	Biomedical (Non-Specialist)	
15	Gamal	Male	Black (Egyptian)	Mathematics (Specialist)	
16	Harriet	Female	White (British)	Mathematics (Specialist	
17	Liz	Female	White (Turkish)	Biomedical (Non-Specialist)	
18	Andrew	Male	Black (Ugandan)	Business (Non-Specialist)	Focus Group B
19	Annabel	Female	White (Hungarian)		
20	Gore	Male	Black (Nigerian)		
21	Kampello	Male	Black (Nigerian)		
22	Vladimir	Male	Asian (Vietnamese)		

3.4.1 The one-to-one and focus groups interviews

Pilot studies help to identify unexpected themes and allow changes to be made if necessary, for example, reviewing the interview questions (Gerson and Horowitz, 2002). I carried out pilot interviews using a small number of mature students. Based on the analyses of the pilot, I reviewed some of the questions to suit non-native English-speaking students, revised their order and developed more probing questions (Appendix 2, p.216).

The pilot study also helped me improve my interviewing techniques. For example, instead of agreeing to the responses and completing interviewees' sentences I asked for further explanations of whatever was said. Following this, the in-depth interviews of the 2008/9 cohort of students took place between the period of September 2009 and March 2010; while both focus group interviews were conducted on the 2009/10 cohort of students during February/March 2010. Each in-depth interview lasted between 45 and 65 minutes, while the focus group interviews took 80 and 90 minutes for groups B and A, respectively.

The in-depth interview focused on three areas identified from the literature review on the learning of mathematics (a copy of the interview schedule is given in Appendix 2, p.216). The three areas were:

- The interviewee's perception of mathematics as a subject
- The interviewee's educational experience in general
- Their experiences of learning mathematics module(s) at university

The aim of the interviews was to identify the discourses of learning of mathematics used (or employed or taken up) by mature students. As such the interviews were focused around questions that enabled me to examine: how mathematics was perceived by the interviewees, their parents or guardians, friends, teachers and people around them; how they felt about mathematics when compared with other subjects; how their educational background shaped their learning of mathematics and perceptions; their feelings regarding the status of mathematics in general; and the factors that they felt positively or negatively contributed to their learning of mathematics, both at school and university levels. The same themes were explored in all the interviews with follow-up questions, as necessary, probing their performances and aspirations for the future.

Members of the focus groups also discussed these questions and they were asked to discuss their experiences of factors that they believed enhanced or slowed their learning of mathematics. As expected, among the participants of the focus groups, there were exchange of ideas and fierce debates on certain issues. The participants freely discussed and shared their views about mathematics and the possible reasons as to why some people feel challenged by mathematics. The interviews were transcribed in full and coded according to the emerging themes. This was used to identify the discourses employed by the participants. The procedures in the interviews and the steps used (Appendix 2, p.216) were documented as an indication of the validity (accuracy of findings) and reliability (consistent approach) of the qualitative data (Yin, 2003). The full detail of the analysis of the interviews and focus group is given in the Data Analyses chapters.

3.4.2 The questionnaire

Based on the partial analysis of the first-phase data from the interviews, the second-phase of the research was a questionnaire with 33 statements, constructed to help further examine the responses. This collected data from a larger number of first year undergraduate non/specialist students who did at least one mathematics module in the same year. Respondents were asked to respond to each statement on a five-point Likert scale degree of agreement rating scales of 1 = Strongly Disagree to 5 = Strongly Agree. The questionnaire was piloted with a dozen selected first year students. Based on this, slight revisions were made to some of the wording, the order of the questions and the layout of the questionnaire. The 33 statements/questions were broadly categorised under the following headings (Appendix 3, p.218). They are:

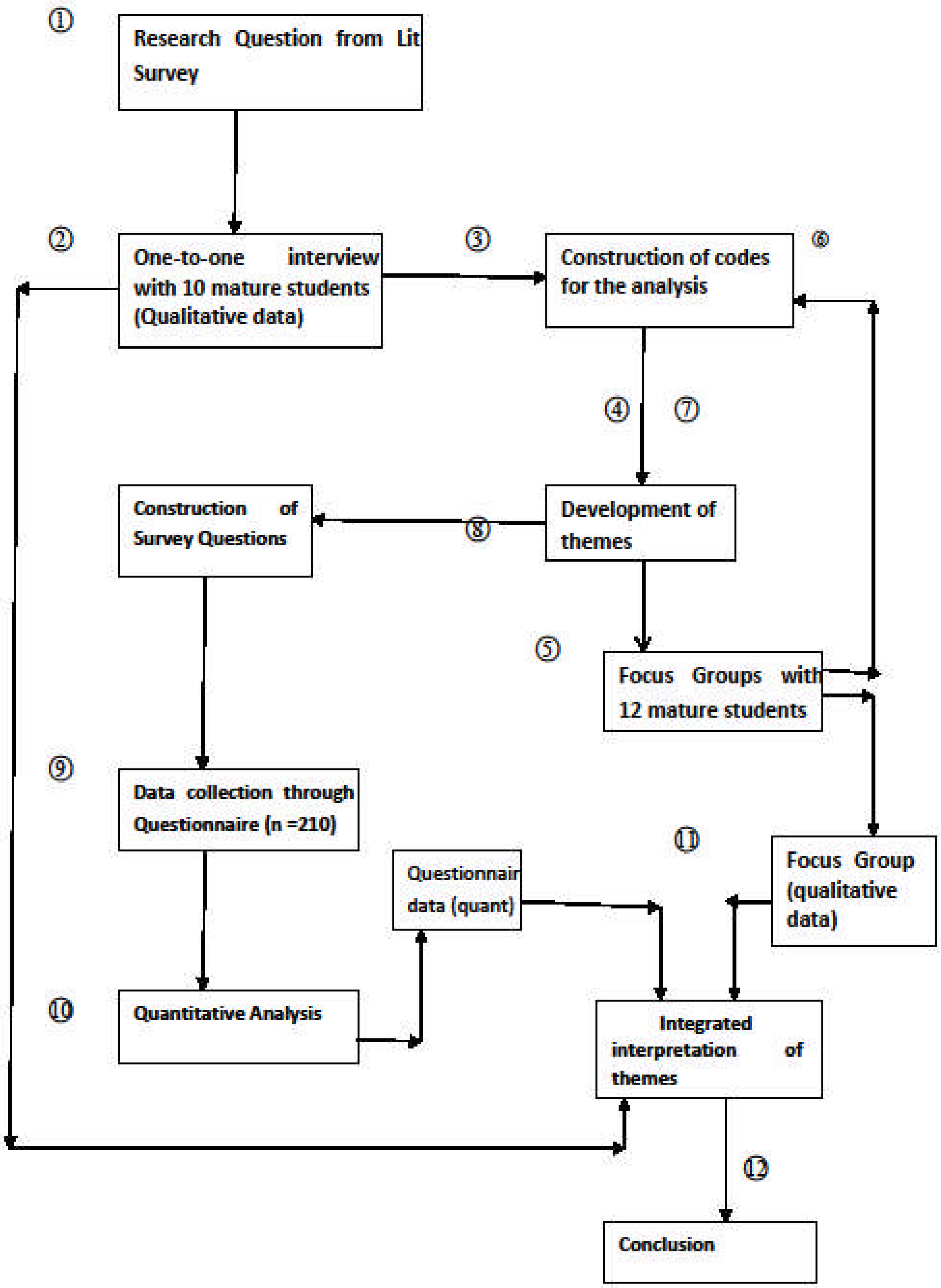
- *The Perception of Mathematics*: Participants expressed their agreement by choosing one of the options given for each of the seven questions about the perception of mathematics;
- *The Value of Learning Mathematics*: Seven questions involving the perceived values given to the learning of mathematics and participants were asked to express their views;
- *Environments That Help Learn Mathematics*: Seven questions that required the participants to identify learning environments based on their past experiences that enhanced their learning of mathematics; if the listed experiences did not match their own they could choose 'None of the above apply to my experiences' (but this option was not included in the analysis because nobody chose it);
- *Strategies for Learning Mathematics*: From seven options, participants were asked to choose strategies they had found personally effective when learning mathematics;
- *Factors Affecting the Learning of Mathematics*: Six questions asking participants to choose the factors they could identify with from their own past experiences.

Colleagues encouraged the students to complete the questionnaire independently and collected completed forms. Similar procedures were followed at both campuses. As pointed out in Section 3.4, 84% of the distributed questionnaire was found to be valid. The results obtained from the qualitative and the quantitative analyses were analysed as demonstrated in Chapter Four. The order of the data production and the integration of the analyses are summarised in Figure 3.1(p.64).

3.5 Ethical considerations

There were several ethical issues that needed to be addressed in this study, around the safety of the participants, obtaining informed consent, confidentiality and anonymity of the participants, and the power relations between myself and the participants. I lodged an application for permission to carry out the investigation with the university's ethical panel, which was granted. The physical safety of the participants was protected, since all the interviews were conducted and the questionnaire completed within the university's premises. In some cases the interviews took place in pre-booked classrooms and at no times were the participants exposed to any physical risk or danger. As described in Section 3.4, informed consent from each participant was obtained. I first disclosed the purpose of my investigation, then the interview procedures and the expected benefit for students doing mathematics. I made sure that the participants understood the explanation, provided it in writing (Appendix 1, p.210), gave them opportunities to ask questions and ensured their confidentiality and anonymity. The participants were asked to voluntarily sign the consent form (Appendix 1, p.210) and all consent forms had been read and signed before the interviews took place. As pointed in Section 3.1, the source of data for my investigation was students who I taught in the spring term of 2008/9 or in the autumn and spring terms of 2009/10. As an 'insider' I had a great deal of information about the performances, attendance patterns, etc. of each student. I also had an intimate knowledge of the context of the investigation and understood the stress that some students had experienced when learning mathematics. Although I was an 'insider' I was also an 'outsider' by my position of being a member of the teaching staff. Thomas, *et al*. (2000) argues that the position of the researcher raises ethical issues. I have considered how my 'insider/outsider' positions have shaped the responses of the students who took part in my investigation.

Figure 3.1 Flow diagram showing the different stages of data collection and analysis



It is obvious that my position as an ‘insider’ gave me the advantage of executing the interviews from a position of having enough information and knowledge of the context of the study. This position enabled me to ask more probing questions and gauge the non-verbal signals from the participants. For instance, institutions require students to attend lectures and seminars regularly as it contributes towards success in examinations. But, a participant who was non-regular attendee of lectures and seminars could also speak highly of the advantages of regular attendance. As an insider, and knowing the status of the participant’s attendance culture, I could probe to find out the cause of non-attendance (Punch, 2005). I was able to project the extraneous factors affecting the learning of mathematics and provide more accurate interpretation of the experiences of mature students. However, there was the possibility that this could create a misrepresentation of the ‘voice’ (Silverman, 2010) of the participants. It was my responsibility to conduct personal reflexivity that involved reflecting upon the ways in which my own values and interests had affected my interpretation of the voices of the participants. Reflexive practice is one way of creating a space within which the respondents can tell their stories as well as increase the understanding of those stories by the interviewer (Bourdieu, 1996).

I also considered the ethical issue related to the lecturer/student power relation that existed between us. It could be argued that the power relation (Foucault, 1980) that positioned me as a lecturer could have influenced the responses to the interview questions and the questionnaire that the students gave. However, when the interviews took place the direct power relation of lecturer/student had been minimised with the students who participated in the interviews; I was not involved in teaching them anymore. Nevertheless, I was still teaching the students who participated in completing the questionnaire. I argue that the power relation between these students and me (or my colleagues who were overseeing the administration of the questionnaire) was focused on facilitating the smooth running of the completion of the questionnaire. Nevertheless, I recognised the power relations and potential effects involved and tried to be sensitive to these issues (Francis and Archer, 2005). I continued to be aware of the ongoing relationship between us and make deliberate attempt not to influence their responses to the research questions.

As an ‘insider’, I knew the performances in the MA / QM modules of each interviewee; their engagement during the lecture; and their facial expressions of approval/disapproval in the lecture that ‘spoke’ louder than articulated words. I had to reflect on my actions and work very hard to make sure that such memories have the minimum effect during the interviews and create an environment where the interviewees could freely tell their stories and experiences of learning mathematics with very little influence or input from me. I recognise that knowledge, views and memories that I as a teacher bring to the interviews could shape the data collection and its interpretation. This cannot be eliminated completely but personal reflexivity could help minimise its effect. Ahern (1999: 408) said, ‘The ability to put aside personal feelings and preconceptions is more a function of how reflexive one is rather than how objective one is because it is not possible for researchers to set aside things about which they are not aware’.

As a male black person, I am aware that research questions around ethnicity and gender (see p. 166) could be sensitive to some of the participants: some students could react by giving replies that they did not experience; while others might provide answers that they think I preferred. There is no means of ‘proving’ or ‘disproving’ the facts of the stories and experiences told by any one of the 22 who participated in the interviews. However, there is a hierarchical relation between the interviewer and the students (Fontana and Frey, 2000) which needs to be negotiated continuously. The students are in a position of power since they could opt not to respond to a particular question; choose the setting for the interview time when the interviews could be done (Barbour, 2007); and could control in releasing their stories at the data collection stage. I emphasised to the students before the interviews that my role as a lecturer or a male black researcher should not influence their responses to the research questions. I explained that they were co-participants in trying to help me answer the research question. I also pointed out the potential benefits to students and to the institution that could result from my research and encouraged the students to collaborate in this effort to unlock the factors that are perceived to be the main sources of the challenges faced by mature non-specialist students in learning mathematics.

3.6 Summary

The main research question was addressed by collecting primary data using in-depth and focus group interviews and a questionnaire constructed for this purpose. A total of 22 participants (73% non- specialists and 27% mathematics specialists) in the interviews (10 for in-depth and 12 for two focus groups) were selected from the 2008/9 and 2009/10 entries of first year undergraduate students. The interviews took place in the university's premises from September 2009 to March 2010. Thematic analysis was carried out on the qualitative data collected by the interviews. The questionnaire was distributed in April/May 2010 among 250 first year undergraduate students of the 2009/10 entry of the Biomedical (26%), Business (46%) and Mathematics (28%) students. 210 completed and valid questionnaires were received and the quantitative data then collated and entered into SPSS for analysis. The breakdown of the percentage of participants in each subgroup is summarised in Figure 3.2 below.

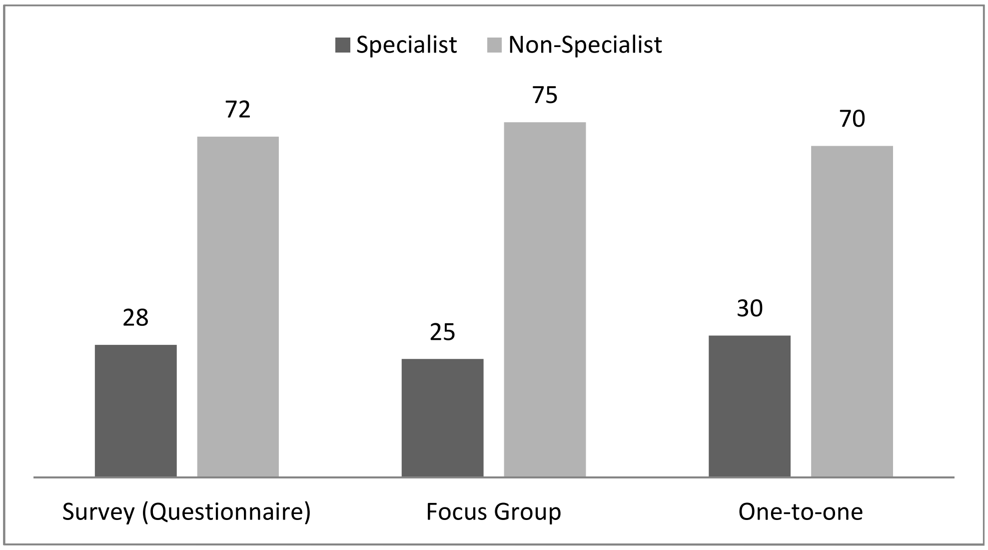


Figure 3.2: Summary of the percentage of participants in each subgroup

The production of the data and the steps followed in the analysis is summarised in Figure 3.1 (p.64). The sequential exploratory Mixed Methods Research technique was used to integrate the results from the qualitative and quantitative data analyses as demonstrated in Chapter Four. The possible advantage/limitations of the research design and data collecting methods are also highlighted. Some of the ethical issues in the research that could arise from my multiple positions were dealt with using the principles of reflexivity. I had taken all the necessary steps such as informing the participants the purpose of my research, the academic benefit that could be gained from my investigation and encouraging them to openly talk about their learning experiences in mathematics.

Having defined the research design and considered the ethical issues that could arise in the process of data collection and analyses, the next stage is to demonstrate the data analysis performed on the data collected using the data collection instruments.

CHAPTER FOUR

Data Analysis

4.1 Introduction

This chapter describes how the initial data analyses were conducted, and demonstrates how this led to the identification of conceptual themes and the construction of the factors perceived as affecting the learning of mathematics. There were two sets of data to be analysed; the qualitative data collected from the one-to-one and focus group interviews; and the survey data collected from the questionnaire. Each of these analyses is performed independently and then the results, based on the principals of Mixed Methods Research, 'integrated during the interpretation[18] of the outcome of the analysis' (Creswell, *et al.*, 2003: 232). The knowledge being sought within the epistemological context of subjective or objective framework requires either an interpretive or normative paradigm (Cohen, *et al.*, 2003). The interpretive paradigm governs investigations undertaken using qualitative methods, while investigations involving quantitative methods are within the normative paradigm (set rules).

4.2 Qualitative data analysis

4.2.1 Analysis of the one-to-one interviews

The first stage of my qualitative data analysis involved reading the transcripts from the ten one-to-one student interviews through a number of times in order to gain a sense of their overall meaning in relation to answer the research questions. Once this had been done, descriptive coding that 'assigns labels to data to summarize in a word or short phrase, the basic topic of a passage of qualitative data' (Saldana, 2013: 262) is assigned to elements of

[18] Integration is the combination of quantitative and qualitative research within a given stage of inquiry; in this case at the interpretation stage for convergence of the findings (See Figure 3.1, p.64)

each text as demonstrated in Table 4.1 (p.73). These codes were then examined, and groups of codes that collectively represent a broader concept or topical issues were categorized as themes making sure that the themes were sufficiently grounded in the data. These themes were given names that broadly indicated the shared issues. A conceptual framework to explain the research issues was then developed from the themes that have been created. Transcripts were analysed using thematic analysis, a qualitative method used for 'identifying, analysing and reporting patterns (themes) within data' (Braun and Clarke, 2006:79).

For the analysis of each of the in depth one-to-one interviews a coding framework was devised manually. I preferred manual coding the interviews rather than electronics packages like NVIVO or NUD.IST, because my data set was not large enough to require a coding device. The thematic analysis in the thesis is structured in terms of the main themes which emerged from the interviews. Data from all ten participants are included in this analysis; however I have extracted an interview from one of the in-depth interviews to demonstrate how the codes were created.

All the Biomedical Science students required to take Introduction to Data Analysis (MA) as a core module. I asked Carole (**pseudonym**), a mature non-specialist student studying Biomedical Sciences at first year level, how she found her first year modules taught at the University including the MA module. She replied:

> It was big, big shock with the system; haven't been at education. Any way regarding maths: walked the door as a mature student. I enjoyed maths first three weeks abut after 3rd week I absolutely hated it. That made my first experience bad; quiet miserable. Because it reminded me everything all I went through when I was doing my GCSEs and I failed it and all came pulling back. I could remember how poor I was on that subject [mathematics] I haven't done it for so long and it did come back that I realised actually I did not have academic background you should have; but I

> haven't drawn a graph for so since I was 16; so that was 14 years ago for me really; and12 years later, here we are again in the same situation. I have to say I found the whole set of modules quiet difficult because the teaching is for 4 hours, for anybody, mathematics, if you are bright or not or if you have done maths or not , it is just 4 hours statistics. To do those and go to work, after that only very small learning takes place and it is very condensed learning. It should have been broken up. I think a lot of students complained about that. For it to work, it should've been broken a little bit more; or may be doing the dry part of the class first and then doing the easiest topic straight away or tutorial.

The views expressed in this interview with Carole had to be summarised using descriptive codes. I have coded the above interview as shown in Table 4.1 (p.73). Examining the descriptive codes, it can be seen that Carole had difficulties in all the modules ('I found the whole set of modules quiet difficult'). She specifically pointed out that the length of the lectures ('the teaching is for 4 hours for anybody… if you are bright or not or if you have done maths or not') has contributed to making the learning difficult. Carole also thought that other fellow students had 'complained about' the 4-hours of un-interrupted teaching. As regards to mathematics, she admitted that she enjoyed the mathematics taught to her in the first three weeks after which she found it not only difficult but she 'absolutely hated it'. She positioned mathematics as one of her hated subjects and for her a teaching technique that is suitable to her learning is 'doing the dry part of the class first and then doing the easiest topic straight away or tutorial'. The use of the phrase dry could show what Carole thought of mathematics: dry; inaccessible; hard.

Carole also pointed out her identity as a mature student and as having being away from mathematics for a considerable length of time (… 'but I haven't drawn a graph for so since I was 16; so that was 14 years ago for me really') made her 'first experience bad; quiet miserable'. This is because she was reminded of her past experiences while doing GCSE, '…everything all I went through when I was doing my GCSEs and I failed it'. All these came to her in a flash 'all came pulling back. I could remember how poor I was on that subject [mathematics]'. This is the attitude she had towards mathematics and herself.

These codes along with other similar descriptive codes from all the interviews were put together to create the emerging themes. For example, the codes in Table 4.1 point out to the Pedagogy and Attitude of students. This process of creating codes was repeated with the rest of the data (transcripts from one-to-one and focus groups interviews) merging overlapping codes when necessary and putting the codes together to form the themes considered in the analysis chapters. This process is demonstrated in Table 4.8(p.90).

I looked at the data from two focus groups, in which seven and five participants took part; and explain below (Section 4.2.2) how the descriptive codes given to the responses from the focus group interviews were integrated with the codes obtained from the one-to-one interviews to create the overall themes of the interviews.

4.2.2 Analysis of the focus group interviews

Analysis of the one-to-one interviews generated themes that participants of the interview perceived to affect their learning of mathematics. Following the in-depth interviews and noting the emerging views, I then carried out semi-structured focus group interviews, to focus on and investigate the views on those emerging themes. As pointed out earlier two different focus groups, one at each campus, were formed and discussions on the various themes that had been established by the one-to-one interviews were carried out. I transcribed the discussions and noted/marked texts, views and responses that fit the broader themes similar to those generated by the one-to-one interviews or new themes that reflect the views of the focus group participants on the issue under investigation.

Table 4.1. Descriptive codes to summarise the excerpted interview

Data extracted from Carole's interview	Assigned code
It was big, big shock with the system; haven't been at education. Any way regarding maths: walked the door as a mature student.	**Consequence of her identity**
I enjoyed maths first three weeks but after 3rd week; I absolutely hated it. That made my first experience bad; quiet miserable. Because it reminded me everything all I went through when I was doing my GCSEs and I failed it and all came pulling back.	**Past experience in mathematics**
I could remember how poor I was on that subject I haven't done it for so long and it did come back that I realised actually I did not have academic background you should have; but I haven't drown a graph for so since I was 16; so that was 14 years ago for me really; and 12 years later, here we are again in the same situation.	**Perception about herself**
I have to say I found the whole set of modules quiet difficult because the teaching is for 4 hours, for anybody, mathematics, if you are bright or not or if you have done maths or not , it is just 4 hours statistics.	**Reason for the taught modules to be difficult**
To do those and go to work, after that only very small learning takes place and it is very condensed learning. It should have been broken up. I think a lot of students complained about that. For it to work, it should've been broken a little bit more; or may be doing the dry part of the class first and then doing the easiest subject straight away or tutorial.	**Teaching technique**

I have chosen the discussions held by the two focus groups on the theme of 'mathematics is gendered' to illustrate how I used the information from the focus groups. The participants of the one-to-one interviews had differing views on the question of whether or not mathematics is gendered. The sample responses from some members (non/specialists; all names are pseudonyms) of the focus groups on the question 'is *mathematics gendered?*' is given below:

> No, nothing is just for men or just for women. Historically, it is a male-dominated subject. And for me personally, it was the media or films regarding this subject… because of the society…but at the base of it I do not think that men are particularly better in maths than women or women are better in maths than men; it does not exist (Liz, Group A).

> … I mean on equal grounds, it is the girls who are doing much better in maths than us, the boys (Gamal, Group A).

> '…in my school where I studied primary and secondary education, the best marks in the school for maths were scored by female students' (Vladimir, Group B).

> I think, from what I know, girls are slightly better in maths at school age because they do slightly better than boys in lots of subjects, only be by a small percentage, just because, may be they are more dedicated at certain ages than boys (Donald, Group A).

> It all depends on one's ability, and it is just ability. Whether someone is good at it or not, you can't break it down in terms of gender. It is all about your hard work and how good you are with maths. …. you can't say one gender is better than the other… So I don't think there is a gender issue, it just is all ability (Andrew, Group B).

These responses show that views on the issue are as varied as in the one-to-one interviews. For example, Liz referred to historical facts and pointed out that mathematics is a male dominated subject and the media also plays a role in making it appear so but to her '…at the base of it I do not think that men are particularly better in maths than women or women are better in maths than men; it does not exist'. A similar view is expressed by Andrew who makes reference to hard work and ability rather than gender to be good at mathematics. On the other hand, Gamal and Vladimir, referring to their own past school experiences, expressed the view that the girls in their classes were better in mathematics than the boys; and Donald also shares a similar view claiming that the dedication of the girls making them to be slightly better than the boys.

The descriptive codes given to the above interviews are: the impact of gender in learning mathematics; mathematics a male dominated subject; the role of ability in learning mathematics; the role of hard work in learning mathematics. These codes were put together with the codes from the one-to-one interviews to create themes related to Gender and Attitude (see the Data Analysis chapters for details). The analyses from the one-to-one and the focus groups' interviews were put together at the interpretation stage to further strengthen the themes on the issues of mathematics learning.

The analysis in the first phase of the research led to further exploration of the themes constructed from the interviews and a questionnaire with 33 statements was constructed to help study and further examine the themes. For example, the gender issue presented above shows differing views of the participants. In order to get the views from a bigger number of first year students doing the MA and QM modules I asked respondents 'Does the learner's gender affect the successful learning of mathematics'. The quantitative analysis shows that only 7% of the respondents agreed/believed that the gender of the learner affects the learning (Table 4.3, p.80) implying that it is a view held by minority of the students. The methods of analyses carried out on the quantitative data made available from the survey are described below.

4.3 Quantitative data analysis

4.3.1 Introduction

The demographic information about the group of students that were used as the source of the quantitative data is summarised in Table 4.2 (p.77). The quantitative data collected from the survey were analysed using exploratory factor analysis to determine the number and nature of the components necessary to account for the variation in the data. The procedure of Principal Components Analysis was implemented on the responses received from the 210 valid questionnaires that were input into SPSS.

Regression models using the General Linear Model technique were fitted to the Scores generated by the Principal Component Analysis as dependent (response) variables and the categorical variables of Table 4.4 (p.83) as explanatory variables in order to identify their impact on the Scores. A further analysis, Logistic Regression, was carried out for the prediction of group membership or, more generally, for understanding and interpretation of the relationship between a response (to each survey question) and the explanatory variables given in Table 4.4 (p.83). Brief description of each method is given below.

4.3.2 Principal Component Analysis (PCA)

PCA is a data reduction method where the basic idea is to describe a set of given variables in terms of a small number of components. PCA was implemented on the survey data that has 33 survey questions where students were asked to record their responses using the 5-Likert Scale of 1 = Strongly Disagree; 2 = Disagree; 3 = Undecided; 4 = Agree; 5 = Strongly Agree. Based on the category of the survey questions (Appendix 3, p.218), I conducted three separate Principal Component Analyses on the data. The detailed analyses with explanation of the results are provided in Appendix 4 (p.222).

Table 4.2: Breakdown of the demographics collected from the respondents

(M = Male, F= Female and N= Number of respondents for each Gender and Age)

Classification According to	AGE in Years										
	≤ 20		21- 25		26 - 30		31- 40		≥ 41		
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**Total (%)**
Ethnicity											
White	15	18	14	17	1	6	0	0	1	1	73 (36%)
Mixed	2	4	2	0	1	1	0	0	0	0	10 (5%)
Asian	15	11	8	11	0	0	4	0	0	0	49 (24%)
Black	6	5	10	15	6	3	4	7	4	0	60 (30%)
Chinese/Other	1	5	0	3	0	1	0	0	1	0	11 (5%)
N=	**39**	**43**	**34**	**46**	**8**	**11**	**8**	**7**	**6**	**1**	**203**[19]
Area of Study											
Business	16	23	13	20	8	6	5	4	1	0	96 (46%)
Biomedical	12	10	11	13	1	4	2	2	0	0	55 (26%)
Science	12	11	11	15	1	1	1	1	5	1	59 (28%)
N=	**40**	**44**	**35**	**48**	**10**	**11**	**8**	**7**	**6**	**1**	**210**
Domestic Responsibility											
Yes	4	4	4	11	6	6	4	6	4	1	50 (24%)
No	36	40	31	36	3	4	4	1	2	0	157(76%)
N=	**40**	**44**	**35**	**47**	**9**	**10**	**8**	**7**	**6**	**1**	**207**[20]
Working(p/t)											
Yes	19	19	21	24	7	9	4	3	5	0	111(53%)
No	20	25	14	24	3	1	4	4	1	1	97(47%)
N=	**39**	**44**	**35**	**48**	**10**	**10**	**8**	**7**	**6**	**1**	**208**[21]
Pre-Uni. Qual.											
GCSE	11	11	13	12	5	3	6	2	2	0	65 (36%)
A-Levels	25	27	20	28	2	6	0	3	3	1	115(64%)
N=	**36**	**38**	**33**	**40**	**7**	**9**	**6**	**5**	**5**	**1**	**180**[22]
Mode of Study											
Full Time	40	44	31	44	10	8	6	7	4	1	195(93%)
Part Time	0	0	4	4	0	2	2	0	2	0	14 (7%)
N=	**40**	**44**	**35**	**48**	**10**	**10**	**8**	**7**	**6**	**1**	**209**[23]

[19] Seven of the respondents refused to identify their ethnicity.
[20] Three respondents refused to indicate their domestic responsibility.
[21] Two respondents did not indicate whether or not they were working.
[22] A large number, 30, students had qualification different from the indicated in the questionnaire and were not able to fit their qualification to either GCSE or A-levels and opted for 'other' without being specific.
[23] One respondent did not indicate his choice.

If we let the questions in the survey be X_1, X_2, X_3, …X_p , the PCA method generates components Z_1, Z_2, Z_3,…Z_p where each Z_i is a linear combination of the Xs; that is:

$$\mathbf{Z_i = a_{i1}X_1 + a_{i2}X_2 + a_{i3}X_3 + \ldots + a_{ip} X_p; \quad i = 1, 2, \ldots p.} \qquad \textbf{(4.1)}$$

Note that, the components $\mathbf{Z_i}$ are referred to as ‘factors’ in the related technique of ‘factor analysis’. We do not here use this terminology to avoid confusion with the use of the term ‘factor’ in Logistic modelling.

In PCA, the Z_is are uncorrelated. The components hopefully describe different aspects of the data and it is hoped that a reduced number of the p components can be used to adequately describe the variation observed in the data; and the constants in (**4.1**), a_{i1}, a_{i2}, etc. are the elements of the eigenvectors with constraints $\mathbf{a_{i1}^2+a_{i2}^2+a_{i3}^2+\ldots+a_{ip}^2 = 1.}$ The corresponding eigenvalues, λ_i , i = 1,...p are the variances explained by the components where Z_1 has the largest eigenvalue λ_1; Z_2 the next largest eigenvalue λ_2 , and so forth. The graph of the eigenvalues for the ordered components, Z_i, is shown in a Screeplot (p.228).

I have used SPSS to extract the small number of components Z_i less than the number of questions in the survey to describe the entire data. The decision about the number of constructed components to be retained is based both on the default criterion of SPSS where components that have eigenvalues more than 1 and upon educational application and their importance to my study.

On the basis of the results obtained from the analysis of the qualitative data and the magnitude of the eigenvalues of the components, I decided to retain the first eight components extracted by the PCA as shown in Appendix 4 (p.222). The retained constructed components have educational implication and are to be integrated with the perceived factors that affect the learning of mathematics obtained from the qualitative analysis. For example, the qualitative analysis indicates that pedagogy is one of the perceived factors that the participants thought affected their learning of mathematics. On the other hand, the PCA analysis (Table 4.3, p.80) shows that Component 1 is made up of eight variables that are linked with pedagogy. These variables highly load (high correlation coefficient between the component and the variables) on Component 1 and 69% to 90% of the respondents agreed that each variable that made up Component 1 to represent the environment that stimulates their learning of mathematics (Table 4.3, p.80). The integration of the themes from the qualitative analysis and the components obtained from the PCA is demonstrated in Table 4.8 (p.90).

The naming of the Z_i s was carried out by closely examining what the questions that make up each Z_i have in common conceptually. It is possible to see that the demarcation between some of the extracted components is 'thin' and it is not easy to define as demonstrated later in the main analysis.

4.3.3 GLM Analysis

A General Linear Model is a statistical model in which one or more explanatory variables (categorical or continuous) are used to predict outcomes on one outcome (dependent or 'response') variable. The explanatory attributes of the respondents are here categorical (Table 4.4, p.83). The so-called Scores generated by the Principal Component Analysis and obtainable from SPSS output are saved and used here as dependent (response) variables. The Scores indicate the value of a Component from low (negative values) to high (positive values). Since significant tests depend on the normality assumption, preliminary data screening was done to assess whether the assumptions for GLM were seriously violated by the Scores and where necessary appropriate transformations used.

Table 4.3: The responses (in %) of the respondents for each variable and the constructed components with the %variation explained

Variables (items) as in the Questionnaire	Agree[24]	Dis-agree	Constructed component (with %variation explained)
15. Having extra assistance (such as a tutor) available help stimulate my mathematics learning	70	8	(1)PEDAGOGY **(12.82%)**
16. Being in a class of students with similar ability help stimulate my mathematics learning	69	13	
17. A short lecture followed by a tutorial session help stimulate my mathematics learning	74	8	
18. Worked examples with exercises to solve help stimulate my mathematics learning	90	7	
19. A lecture that works at my pace help stimulate my mathematics learning	76	7	
20. The teaching techniques employed help stimulate my mathematics learning	78	4	
26. Attending classes regularly is effective strategy for learning mathematics	84	5	
27. Seeking assistance at an early age is effective strategy for learning mathematics	81	7	
9. Studying mathematics stimulates my thinking, creativity and abstraction	69	13	(2)ATTITUDE/ BELIEF TOWARDS THE SUBJECT (**12.81**%)
10. Studying mathematics will make me more employable and help in my career	76	6	
22. Working hard at it and solving as many problems as possible is effective strategy for learning mathematics	80	7	
23. Understanding basic concepts is effective strategy for learning mathematics	89	5	
24. Developing an interest in mathematics is effective strategy for learning mathematics	71	10	
25. Relating mathematics skills to the real world is effective strategy for learning mathematics	69	7	
8. Learning mathematics is important because I use the skills I learn in my day to day activities	71	15	
28. The learner's natural ability to do mathematics affect the successful learning of mathematics	51	16	
30. The learner's past experience of mathematics affect the successful learning of mathematics	51	21	

[24] The responses ‘Strongly Agree’ and ‘Agree’ are re-coded as ‘Agree’ and similarly ‘Strongly Disagree’ and ‘Disagree’ as ‘Disagree’.

Variables (items) as in the Questionnaire	Agree[24]	Dis-agree	Constructed component (with %variation explained)
31. Support and encouragement of learning mathematics from your family affect the successful learning of mathematics	48	21	(3)BELIEF RELATED TO THE LEARNER **(7.02%)**
29. The learner's attitude & motivation towards mathematics affect the successful learning of mathematics	81	4	
33. Learner's self confidence and belief regarding mathematics affect the successful learning of mathematics	71	8	
11. Achieving C or a better grade in GCSE/A-levels mathematics should be a general entry requirement into universities	68	16	(4) BELIEF ABOUT MATHEMATICS **(6.39%)**
12. My friends and family will respect me if I am successful at mathematics	32	40	
13. People who are good at mathematics are successful in life	28	30	
1. Mathematics is a difficult subject	39	46	(5)PERCEPTION OF MATHEMATICS **(5.77%)**
7. My current perception of mathematics has probably been shaped by what others say about mathematics	20	58	
14. The importance given to mathematics in society is overstated	24	34	
5. People close to me, including my parents, think (or thought) mathematics to be a difficult subject	47	36	(6)PERCEPTION OF MATHEMATICS BY OTHERS **(4.96%)**
6. When I was younger my teachers said mathematics is a difficult subject.	28	52	
3.One needs particular mental aptitudes to be able to do mathematics	46	24	(7)ETHNICITY OF THE LEARNER **(4.95%)**
4. It is likely that some ethnic groups are better at mathematics than others	32	48	
32. The learner's gender affects the successful learning of mathematics	7	73	(8)THE GENDER OF THE LEARNER **(4.48%)**
2. Mathematics is a subject in which male students are more likely to be successful	17	55	
21. Memorizing formulae is effective for learning mathematics	63	18	INDEPENDENT

The estimated fully saturated GLM model, for example, using two independent variables of levels k and m, and S as dependent variable is of the form:

$$\widehat{S_{ij}} = \hat{\mu}_0 + \hat{\alpha}_i + \hat{\beta}_j + (\widehat{\alpha\beta})_{ij} \quad \text{where } i = 1, 2, \ldots, k; \text{ and } j = 1, 2, \ldots m.$$

where the parameter estimates are obtainable from the SPSS output. The GLM procedure available in SPSS was implemented using the forward selection hierarchical model building strategy of main effects followed by 2-way, 3-way and 4-way interactions (see details of the procedures of the strategy on p.241). At each stage of the model fitting exercise non-significant terms are dropped from the model. The details of the variables used in the model building are as shown in Table 4.4 (p.83); and the result from the procedure of the model building on one of the Scores, for example Component 6, (this component is a construct of the perception of others about mathematics) is given in Table 4.5 (p.84) (see Table A4.11, p.252 for the detailed analysis). The model building showed the non-significance of Ethnicity or Age fitted with the other variables. The 'best' model had main effects of Area of Study and Gender with no interaction and the table shows a significant Area of Study effect ($p = 0.026$) but only a mild significance of the effect of Gender ($p = 0.069$). Strictly speaking a model with just the Area Study could be fitted as depicted in Table A4.10 (b) (p.250) but retaining Gender in the model gives better explanation when integrated with the qualitative data. The profile plot of the main effects model Gender + Area of Study (Fig. 4.1, p.84) shows some evidence but not strong evidence from the quantitative data that males have higher level of mean Scores on Component 6 than the females ($p = 0.069$). Further examination of the output (Table A4.11, p.252) shows that the mathematics students, group 3 has a mean Score of 0.295 (standard error 0.131) while the mean Scores of group 1 and group 2 are -0.162(standard error 0.109); and -0.061(standard error 0.137) respectively. Tests (p.260) and Error-Box plot (Fig. 4.1(b), p.85) show that the mathematics group significantly differs in their level of mean score about the perception of mathematics from the remaining two groups, groups 1 and 2 (p = 0.006 and 0.051) respectively.

Similar analyses of model fitting using forward selection was carried out on the remaining seven PCA Component Scores. The analyses showed that models with two main effects and no interaction to be mildly significant for three of the Component Scores; only a single main effect model to be highly/significant for the remaining four Components as displayed in Table 4.6 (p.85); and no model was found to be significant for Component 2. The results from the GLM analyses are used in the following Logistic Regression analysis where identifying the explanatory variables that have effect on each of the response variables that load on the PCA components is considered.

Table 4.4 The explanatory variables used in the model building

Variable	Label with (N, number in the group)
Gender (G)	1= male(92); 2 = female (95)
Ethnicity (E)[25]	1 = White(64); 2= Mixed and other (26); 3 = Asian(45); 4 = Black(52) [Has been reduced to Binary when calculating OR (odds ratio)]
AreaStudy(C)[26]	1=Business (80); 2 = Biomedical (51); 3 = Mathematics (56) [Has been reduced to Binary when calculating OR(odds ratio)]
Age (A)	1 = <20 (77); 2 = 21-25(71); 3 = 26-30(19); 4 = 31- 40(13); 5= >40(7) [Has been reduced to Binary when calculating OR(odds ratio)]

[25] See Table A4.16 – A4.31 pp.264 – 274 for the OR analyses.
[26] The subsequent use of ‘C’ for ‘Area of Study’ is to tighten up for consistency.

Table 4.5 GLM analysis of the Score from component 6 of the PCA

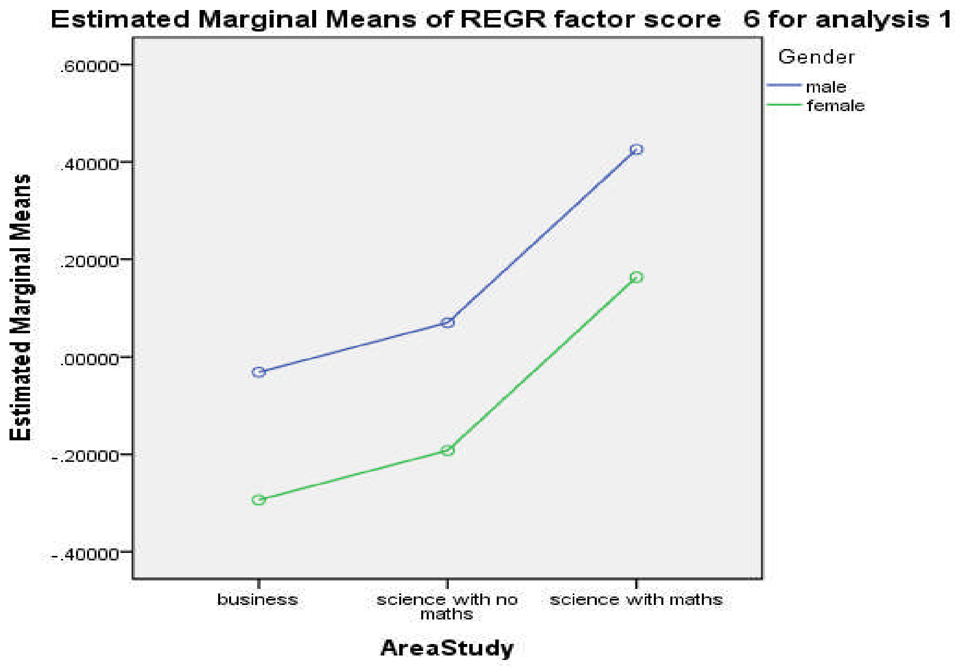
Tests of Between-Subjects Effects

Dependent Variable: REGR factor score 6 for analysis 1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.902[a]	3	3.634	3.798	.011
Intercept	.101	1	.101	.106	.745
Gender	3.202	1	3.202	3.346	.069
AreaStudy	7.139	2	3.570	3.731	.026
Error	175.098	183	.957		
Total	186.000	187			
Corrected Total	186.000	186			

a. R Squared = .059 (Adjusted R Squared = .043)

Fig. 4.1 (a) Profile plot of Gender vs Area of Study



(b) Error-Box plot

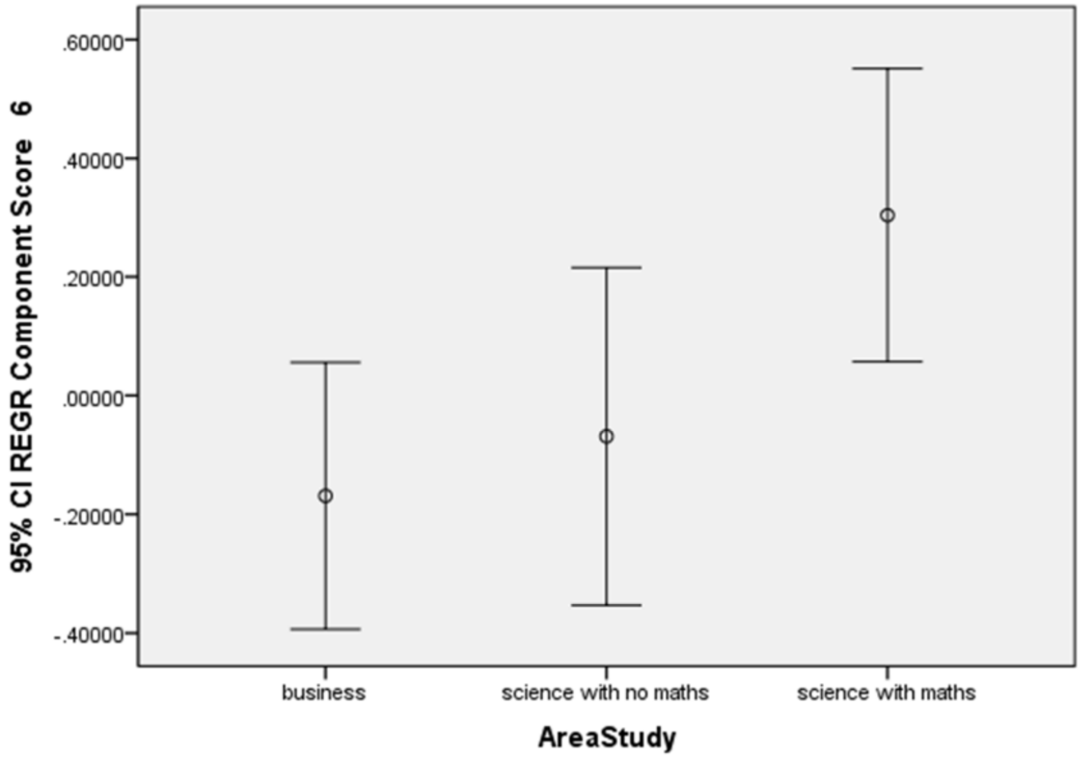


Table 4.6: Fitted models using forward selection method involving the categorical variables to the Scores of the components from the PCA

Fitted Model	Component from the PCA (Table4.3)	'p-to-remove'
Gender (G) +Age (A)	1	0.089 (G); 0.096 (A)
Age (A) + Ethnicity(E)	1*	0.060 (A); 0.052(E)
Age (A) + Ethnicity (E)	5	0.060 (A); 0.052 (E)
AreaStudy (C) + Gender(G)	6	0.026 (C); 0.069 (G)
Ethnicity (E)	3	0.014 (E); not sig. for the rest
AreaStudy (C)	4	0.049 (C); not sig. for the rest
Gender (G)	7	0.000 (G); not sig. for the rest
Gender (G)	8	0.031 (G); not sig. for the rest

*Competing model for Component 1

4.3.4 Logistic Regression Analysis

Logistic Regression is often used to analyse data for which the outcome variable is categorical and binary. It can be used for the prediction of a group membership or, more generally, for understanding and interpretation of the relationship between a response and explanatory variables and or 'factors'[27]. It involves evaluating the odds of different outcomes. In this analysis I have applied Logistic Regression on the response variables (responses of the participants in binary form to each of the survey questions) and the four variables of interest (the explanatory factors age, A; gender, G; ethnicity, E; and course, C). I have applied SPSS Binary Logistic Regression analysis procedure on the recoded explanatory variables (factors) as demonstrated below with two levels of gender, G and two levels of course C (Business and Non-Business).

One of the variables that make up, for example, Component 5 (which is related to the perception of the respondents about mathematics) of the PCA analysis is 'R= mathematics is a difficult subject'. In order to investigate the relationship between the responses to R and the gender (G) of the respondents and the type of course of study (C with level 2) a model is fitted using the method of Backward Stepwise Logistic Regression, starting from the 'fully saturated model'

$$\mathbf{R = G + C + G*C,}$$

The interaction G*C is not significant, G is marginally significant (p=0.07) and C is significant (p= 0.04) as shown in Table 4.7 (p.88). I chose the model G + C as the 'best' model. On this assumption, the estimated odds ratio (OR) for the male students shows that the odds of male students agreeing to mathematics being a difficult subject is 1.7 times that

[27] A factor in Logistic Regression context is a nominal/ categorical explanatory variable.

of the female students. Note that the 95% confidence interval for this odds ratio is (0.95, 3.2) indicating lack of strong significance; while the odds ratio for the Business students to agree that mathematics being a difficult subject is less than one showing that they are less likely than the Non-Business students to agree that mathematics as being a difficult subject; however when the two courses are combined there is an indication of strong significance of course on the responses of the respondents to R[28]. The estimated proportion of respondents agreeing to R could be calculated from the linear predictor using the Logistic Regression parameter estimates (Table 4.7, p.88):

$$\hat{\eta} = -0.153 - 0.634\text{ C } (= 1, 0) + 0.555\text{G } (= 1, 0).$$

The estimated probabilities for R= 1 (Agree) considering gender (G) and Course (C) are calculated using: $\hat{P} = \frac{e^{\hat{\eta}}}{1+e^{\hat{\eta}}} = \frac{1}{1+e^{-\hat{\eta}}}$ (**Appendix 4, p.222**)

and the following values are obtained:

P(R=1/ Male (=1), Course (=1)) = 0.44;
P(R=1/ Female (=0), Course (=1)) = 0.31;
P(R=1)/ Male (=1), Course (=0)) = 0.60;

The estimated probabilities indicate that the male students in each Course are more likely to agree to R than the female students. The probabilities and the estimated OR available from the model fitted by SPSS are used to provide further explanation to the results from the qualitative analysis. The implication of the indicated position of the male students is considered in detail in the analyses chapters. Similar analyses were carried out on variables that were found to have impact on some of the Scores and are given in Appendix 4 (Tables A4.16 - A4.31; p.264 - 274).

[28] Unless stated, the explanation given about the 95% confidence intervals for the odds ratio estimates applies to all similar intervals for the odds ratio considered in this thesis.

Table 4.7: Logistic Regression of R on G and C

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
	Gender(1)	.555	.308	3.237	1	.072	1.742	.952	3.189
Step 1[a]	Course(1)	-.634	.310	4.194	1	.041	.530	.289	.973
	Constant	-.153	.260	.347	1	.556	.858		

a. Variable(s) entered on step 1: Gender (1= Male; 0 = Female), Course (1= Business; 0= Non-Business)

Model if Term Removed

Variable		Model Log Likelihood	Change in -2 Log Likelihood	df	Sig. of the Change
Step 1	Gender	-119.810	3.266	1	.071
	Course	-120.302	4.252	1	.039

4.4 Integrating the findings from the qualitative and quantitative analyses

The eight Components constructed by the PCA are what students perceived about mathematics as a subject and its learning. Some of the variables that load on these Components are integrated with the themes obtained from the qualitative analysis. I have demonstrated (Table 4.8, p.90) how the integration was done by taking two of the seven factors, Pedagogy and Attitude that were perceived by the students to affect their learning of mathematics. As detailed in the data analyses chapters the variables that make up the Components of the PCA have been better understood from the themes of the interviews and vice versa while the level of acceptance/popularity of the themes of the qualitative analysis among the students covered in the study are provided by the quantitative analysis.

The first two Components in the PCA relate to Pedagogy (what students expect from the institute and what they need to do when learning mathematics) and the Attitude and belief of the learners towards mathematics. These two Components as shown in the PCA explain nearly 26% of the variation in the survey data (Table 4.3, p.80). For the sake of convenience and their importance (in reference to the high percentage of variation explained) Pedagogy and Attitude are labelled as **Factor 1** and **Factor 2** respectively and are grouped as the first set of factors perceived to affect the learning of mathematics; and discussed in detail in Chapter Five.

The next four Components of the PCA relate to the Beliefs that the students have about themselves, the Beliefs about the subject, the Perceptions of the respondents and the Perceptions of others about mathematics; they together explain about 24% of the variation in the survey data (Table 4.3, p.80). Some of the variables that make up these Components are integrated with similar themes from the qualitative data and are labelled as **Factor 3, Factor 4** and **Factor 5**, respectively. These factors are grouped as the second set of perceived factors to affect the learning of mathematics and discussed in Chapter Six.

The final two Components of the PCA relate with issues related to Ethnicity and Gender of the learner. Although the two Components together explain less than 10% of the variation (Table 4.3, p.80), the variables that make up these Components match with ethnicity and gender issues raised in the qualitative data. I have included and labelled them as **Factor 6** and **Factor 7**, respectively. These two factors are grouped as the third set of perceived factors; and are the topics of Chapter Seven.

The method of analysis explained above has been implemented in the Data Analyses chapters that follow.

Table 4.8 Integration of some of the results from the Qualitative and Quantitative analyses related to Pedagogy (Factor 1) and Attitude (Factor 2)

Codes related to Pedagogy/ Attitude from the one-to-one and focus group interviews	**Themes (Pedagogy and Attitude)**	**Variables from the PCA related to Pedagogy (Factor 1) and Attitude (Factor 2) with % of agreement**
The teaching is for 4 hours for anybody; a little bit more time allocated to the tutorials; two hours of straight teaching is too much (**Section 5.2.1**)	Length of lecture and tutorial times	A short lecture followed by a tutorial session **(74%);** the female students are more than twice to agree than the male students and the younger students are 1.6 times more likely to agree than the mature students.
The pace was too fast for the majority of us; very little time to assimilate; extra time given in class; maths is a different language and needs more time; it is taught at a fast pace (**Section 5.2.2**)	The pace of the lecture	A lecture that works at my pace **(76%);** the female and the younger students are 1.9 and 2.9 times more likely to agree than the male and younger students respectively
The teacher's inability to control the class; they didn't want to teach us; my favourite teacher would bring me work; a teacher who wasn't quite seem to be on the ball; the lecturer said this module is hard; had a teacher who did not care for maths; teachers lenient; teacher knocks you because you don't know something basic; my teacher made me love the subject (**Section 5.2.3**)	Teachers' actions	Attending classes regularly **(84%);** the female and the younger students are 1.9 and 2.9 times more likely to agree than the male and younger students.

Codes related to Pedagogy/ Attitude from the one-to-one and focus group interviews	**Themes (Pedagogy and Attitude)**	**Variables from the PCA related to Pedagogy (Factor 1) and Attitude (Factor 2) with % of agreement**
Two different classes one for mature students and another for the rest; I am really determined and positive; low level of confidence; mathematics is too clinical and not for me (**Sections 5.2.2& 5.3.3)**	Confidence and determination	Being in a class of students with similar ability **(69%);** the female students are 1.1 times more likely to agree than the male students. learner's self confidence and belief regarding mathematics **(71%);** the male students are 1.8 times more than the female students to agree while the younger students are 1.3 times more likely to agree than the mature students.
Doing the dry part first and then the easiest; the way the teachers usually taught; did not have any idea about the system they are teaching (**Section 5.2.1**)	Teaching style	The teaching techniques employed **(78%);** both the female and the younger students are more than twice times to agree than their counterparts the male and younger students.
something that you have always to practise and remember what has been said in class; asking questions; spent a lot more time on QM; I practise in the tutorial but later I cannot remember (**Section 5.2.2**)	Learning methods	Worked examples with exercises to solve **(90%);** the mature students are 1.3 times more likely to agree than the younger students while the female students are twice more than the male students to agree.

Codes related to Pedagogy/ Attitude from the one-to-one and focus group interviews	**Themes (Pedagogy and Attitude)**	**Variables from the PCA related to Pedagogy (Factor 1) and Attitude (Factor 2) with % of agreement**
I had a private tuition at home; good foundation and support from family; no support from family; negative experience from family (**Sections 5.3.3 & 6.2.1**)	Academic support	Having extra assistance (such as a tutor) available **(70%);**the younger students are more than twice to agree than the mature while the male students are 1.1 times to agree than the female students. the learner's past experience of mathematics **(51%);** the younger students are 1.8 times more likely to agree than the mature students
The students do not do enough exercise; mathematics more difficult and the fear of failing it; perception that mathematics is complicated; not in my DNA; no passion for it (**Section 5.3.1**)	Disengagement from mathematics	Seeking assistance at an early stage **(81%);**both the female and younger students are nearly more than eight and four times likely to agree than their counterparts respectively the learner's attitude and motivation towards mathematics **(81%);** both the male and the younger students are more likely to agree (OR=1.1 and 1.4 respectively) than the female and mature students**.**
I realised that I was not naturally good in mathematics; I cannot do maths (**Section 5.3.2**)	Negative emotion	The learner's natural ability to do mathematics **(51%);** the younger students are 1.4 times more likely to agree than the mature students.

4.5 Summary

This chapter described how the two sets of data, collected from the one-to-one and focus group interviews and the survey data collected from the questionnaire were analysed; and the results from the analyses pulled together for convergence of the findings. The analysis led to the identification of conceptual themes and constructed Components from the Principal Component Analysis (Table 4.3).

Based on the principles of sequential exploratory Mixed Methods Design which is characterised by an initial phase of qualitative data collection and analysis followed by a phase of quantitative data collection and analysis, seven factors were perceived to affect the learning of mathematics (Section 4.4). The convergence of the findings from the qualitative and quantitative analyses was demonstrated by an example (Table 4.8). The views of the students regarding the factors identified were dependent on the student's gender, age, ethnicity and the course studied as demonstrated in Table 4.6. The impact of these categorical variables on the views about the factors have been analysed using the GLM and Logistic Regression analyses as demonstrated in Sections 4.3.3 & 4.3.4.

CHAPTER Five

First Set of Factors: Pedagogy and Attitude

5.1 Introduction

In this chapter I pull together the information made available from the qualitative and quantitative data sets in order to address my research question 'Why do some mature non-specialist undergraduate first year students taking mathematics as an ancillary subject find mathematics challenging and fail to pass it?' Based on poststructuralist approach described in Section 2.2, the biographical data obtained from the interviews were used to interrogate/identify the prevailing discourses taken up by the mature students in their journey of learning mathematics. The two constructed factors, Factor 1 and Factor 2 that emerged from the qualitative and quantitative data are discussed in Sections 5.2 and 5.3 respectively.

5.2 Factor 1: Learner centred pedagogy

Following the integration of the themes from the qualitative and quantitative analyses as described in Section 4.4, Factor 1 was perceived by the participants and the respondents to promote successful learning in mathematics. In the one-to-one interviews, I asked the participants to share their experiences when doing the mathematics modules, with regards to the methods employed in the delivery, pace and length of the lecture, nature of the tutorial, etc. as seen in the scheme of the interviews (Appendix 1, p.210). The following themes emerged from the interviews: the length of the lectures and tutorials; the pace of the lecture; and teachers' actions. These themes are matched to the variables that make up Component 1 of the PCA. Component 1 is made up of eight variables (Table 5.1, p.95) and could be conceptualized to represent the general pedagogy that learners agreed will stimulate their mathematics learning (Table 4.3, p.80). As described in Chapter Four, the

GLM analysis on the component Score of Component 1 obtained from the PCA indicates two competing models, age with ethnicity and age with gender (Table 4.6, p.85). The table shows that the impact of age and ethnicity is more significant than age and gender. Further analysis on the pattern of responses to the variables that make up Component 1 (Table 5.1, p.95) is examined by conducting Logistic Regression analysis (Tables A4.16-26; pp.264 - 271) and the results have given a better understanding of the issues raised in the interviews as described in Section 5.2.1 on the next page.

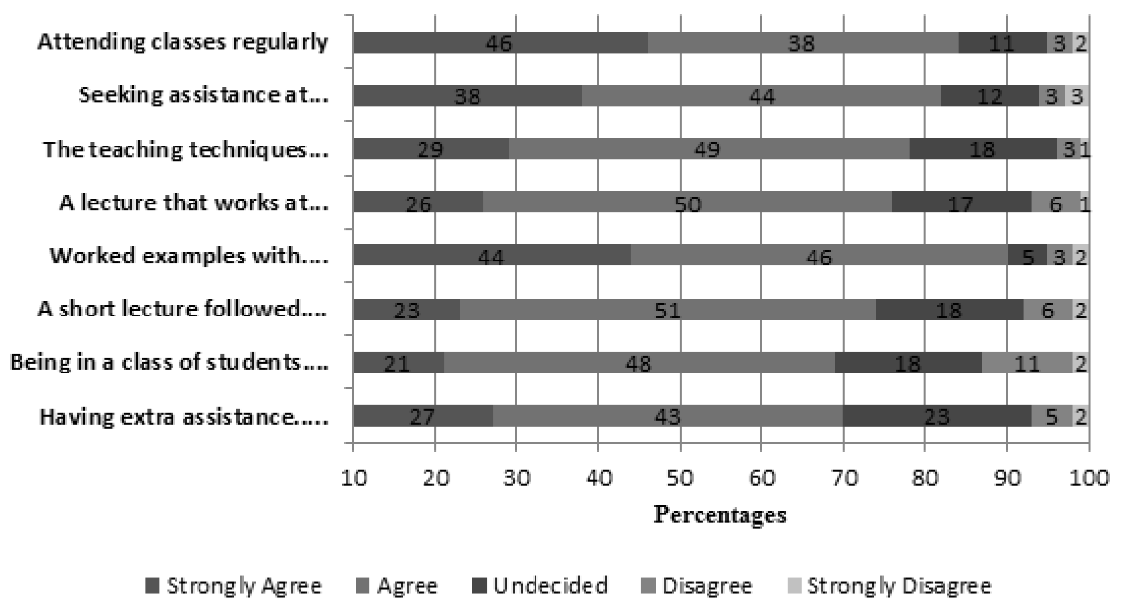
Table 5.1 Variables from the Quantitative data that load on Component 1

Variables that load on Component 1
18. Worked examples with exercises to solve help stimulate my mathematics learning **(V1)**
17. A short lecture followed by a tutorial session help stimulate my mathematics learning **(V2)**
16. Being in a class of students with similar ability help stimulate my mathematics learning (**V3)**
19. A lecture that works at my pace help stimulate my mathematics learning (**V4)**
20. The teaching techniques employed help stimulate my mathematics learning (**V5)**
27. Seeking assistance at an early age is effective strategy for learning mathematics (**V6)**
26**.** Attending classes regularly is effective strategy for learning mathematics (**V7)**
15. Having extra assistance (such as a tutor) available help stimulate my mathematics learning (**V8)**

Table 4.3 (p.80) shows that 69% to 90% of the respondents agreed that the environment expressed by the variables V1 - V8 (Table 5.1) stimulate their learning of mathematics; the details of the breakdown of the percentages is shown in Figure 5.1 (p. 96). Component 1 is made up of the ‘done to them’ and ‘done by them’ variables which characterize the pedagogy that is friendly to learners of mathematics; and the responsibilities expected from the learners in order to make the teaching and the learning fruitful. In the pages that follow I examined the narratives given by the participants of the one-to-one in depth and the two

focus groups interviews to find out how the pedagogy practised by the ‘agents of teaching’ (Davies, 1990) made the learning of mathematics problematic or easy for the learners.

Figure 5.1 Respondents' responses: In my experiences, I find the following environments help stimulate my mathematics learning



5.2.1 The lengths of the lecture and tutorial times

As pointed in Table 4.8 (p.90) the quantitative variable that is related to the lengths of the lecture and tutorial times is V2 (17. *A short lecture followed by a tutorial session help stimulate my mathematics learning).* The quantitative analysis shows that 74% of the respondents agree with V2 and further analysis using Logistic Regression (Table A4.17, p.265) shows that the regression coefficient for gender is weakly significant ($p = 0.099$). The percentage of agreement with V2 is higher for the female students than the male’s (80% and 68%, respectively); while looking at the estimated odds ratio statistics (Table A4.17, p.265) the female students are more than twice to be in favour of V2 (OR= 2.4 with a 95% confidence interval (0.8, 6.9)) when compared with their male counterparts; and the estimated odds of the young students favouring V2 is slightly higher (OR= 1.6 with a 95% confidence interval of (0.5, 4.7)) when compared with the mature students'. The fact that the 95% confidence intervals of the ORs are so wide suggest that because of the small sample size the estimates of the ORs are not very precise. The estimates of the conditional probabilities using equation A4.3 (p.243) are: P(Agreeing to V2/ Female and young) = 0.952 and P(Agreeing to V2/ Male and mature) = 0.840, also support what the observed odds ratios indicated. V2 is supposed to appeal to those students whose learning style favoured interacting with the lecturer or fellow students to construct knowledge rather than being passive listeners. Besides, some of the mature non-specialist students who participated in the interview, namely Elsa, Carole, Martha, Faith, Simon and Marr, have also expressed agreement with V2 (see below). In agreement with Smith (2002), they believed that a longer tutorial session was needed to interact with fellow students or the lecturer to assimilate and construct mathematical knowledge. The participants argued that the support that they get on individual basis during the tutorial session also contributed to building their confidence in the subject; the detailed discussions on the identification of themes and the prevailing discourses behind each theme are discussed below.

Carole and Simon were non-specialist members of the one-to-one interview group. I knew Carole when she was doing the Foundation Mathematics a year earlier. She was admitted to the present course through the widening participation programme. She regularly came to my office seeking help in her mathematics. On the other hand, Simon was one of the students who frequently used to interrupt my lectures to ask questions. I purposely invited both of them to take part in this interview. Drawing on their experiences, Carole and Simon challenged the present arrangement of equal or more hours to the lecture than to the tutorial sessions. Responding to my question Carole said:

> ...I have to say, I found the whole set of modules difficult because

> the teaching is for 4 hours; for anybody, if you are bright or not or if you have done maths or not, it is just 4 hours statistics.... only very small learning takes place and it is very condensed learning. I think a lot of students complained about that. For it to work, it should've been broken a little bit more times for the tutorial; or maybe doing the dry part of the class first and then doing the easiest subject [topic] straightaway or [a] tutorial... (Carole, White, Female, Biomedical Sciences, in-depth interview).

Carole pointed out that regardless of the learner being 'bright/not bright' or has had 'maths/no maths', a lot of students including herself complained about the 4-hours teaching of mathematics to be long for everybody. Carole might have considered herself not being 'bright' or not have enough experience in mathematics; and lost confidence in herself. As described in Section 2.2, a poststructuralist approach provides a way of examining how each person actively takes up the discourses that position them or how they are positioned within a discourse. In Carole's case, the dominant discourse about mathematics (the accepted way of looking at mathematics being for elite learners or for learners with natural/innate ability) could eventually have led her to fear mathematics, convinced that only 'elites' can learn it; this is because she might have heard this discourse of mathematics repeatedly and she accepted it; and made her to take a position of not being bright enough to do mathematics. Mathematics as a subject constructed thus has affected the beliefs and confidence of Carole. As highlighted in the literature review, to be successful in mathematics learning, the literature suggests that learners need to have confidence in themselves (McLeod, 1992; Smith, 2002). Zan (2000) studying biology students doing mathematics concluded that the students within themselves had 'loser beliefs' and failed the mathematics module repeatedly while the students reported by Mulat and Arcavi (2009) were successful in mathematics because of their positive belief about mathematics and their determination (Section 2.5).

Carole, agreeing with the view of her classmates about the length of the lecture, thought that very little learning took place in the MA module. She suggested a change in the allocated time for the module where the 'dry/easy' topics are done. This is an indication of her belief that her learning was constrained by an inconvenient scheduling of the module and consequently suggests that the current 4-hour session be broken up into activities that enhance learning. For example, one of her suggestion was for a short session for delivering a lecture based on theories, what she called the 'dry' part, and then a longer tutorial session. Her use of the word dry could indicate that she perceived mathematics to be hard, inaccessible and difficult; she was not in favour of the theoretical aspect of the mathematics she was doing. In support of Carole's view, Simon (Nigerian, Male, Finance and Banking, in-depth interview) said, '...for me, two hours of straight teaching is too much as very little learning takes place' and suggested making the lecture shorter and more time allocated for the tutorials.

From the two accounts given above, it could be said that the pedagogy should be learner-friendly, to the extent that it should allow time to accommodate personal studies. Both Carole and Simon suggested they felt a shorter lecture followed by a tutorial session of an (unspecified) length would stimulate learning. From Figure 5.1 (p.96), the view 'a short lecture followed by a tutorial session help stimulate my mathematics learning' is one of the variables widely held among the respondents of the questionnaire where 74% of the respondents agreed or strongly agreed (hereafter, for easier interpretation the percentage of responses agree/strongly agree and disagree/strongly disagree are replaced by agree and disagree respectively).

The next theme that emerged from the discussions was a cause for concern amongst the participants.

5.2.2 The pace of the lectures

The variable from the quantitative analysis that is related to the pace of the lectures is V4 (19. *A lecture that works at my pace help stimulate my mathematics learning*) and 76% of the respondents agree with V4. The percentage of female respondents agreeing with V4 is 79% while the figure for the male respondents is 71%. The estimates of the odds ratio (Table A4.19, p.266) show that the female students were 1.9 times (with 95% confidence interval of (0.6, 5.6)) more likely to agree with V4 than the male respondents; and the younger respondents were nearly three times (with 95% confidence interval of (0.8, 10.8)) more likely to agree with V4 than the mature respondents.

The pace of the lectures that some of the students experienced in their mathematics classes did not fit their preferred learning styles. Some students needed more time to assimilate what had been said during the lecture than others. The impact of the pace of the lecture on their learning had been described by some of the participants, as the discussion given below shows.

Elsa, a non-specialist participant, speaking about the pace of the mathematics lectures said:

> The pace was too fast for the majority of us mature students, ... we have very little time actually to assimilate the topics … discuss and share topics with colleagues...also if the pace of teaching is slower, then the understanding [of the mathematics] gradually comes. I felt and all of my friends also felt, as mature students, if we were given the extra time, maybe in the class, or maybe set [in] two different classes, one for us mature students and another for the rest of the students... (Elsa, Ghanaian, Female, Biomedical Sciences, in-depth interview).

Smith (2002) states that new knowledge could be incorporated into existing knowledge with a sufficient time allowed. In line with this, Elsa felt frustrated with the lack of adequate time to assimilate what had been learnt in the classroom. She had experienced that the speed at which assimilation was expected to happen was not appropriate to learners like her; and in line with discourse of setting students in ability groups, she suggested a differential approach between mature and the rest of the students, where mature students were given the extra time. However, the discourse of putting students into different ability group is the most visible way of influencing students' identity of engagement in mathematics. This differential approach reinforced Elsa's view of academic segregation where mature students are taught separately from younger students. On the basis of the views of her classmates, she also believed that having a separate class for mature students would enhance the learning of mathematics by creating an environment that helped to comprehend topics covered; and they do not have to see the younger learners as a constant benchmark which they could not live up to.

Elsa also thought that the pace of teaching did not allow the construction and assimilation of knowledge to take place. 'We learn best when we actively construct our own understanding' (Pritchard, 2005:22) and the situation highlighted by Elsa exhibited 'dissonance' (Ajzen, 1988) in mismatching learning engagement of the mature students and their learning pace. The dissonance, as suggested by Elsa, could be reduced by having a separate class for mature students only. V3 (16. *Being in a class of students with similar ability help stimulate my mathematics learning*) is the variable that relates to having a separate class argued by Elsa. 69% of the respondents agreed that being in a class of students with similar ability stimulates their learning; in particular 68% and 70% of the male and female respondents respectively and 73% and 67 % young and mature students respectively agreed with V3. The Logistic Regression given in Table A4.18 (p.265) show similar conditional probabilities for the male and female groups [P(Agreeing to V3/Male and mature)= 0.833 and P(Agreeing to V3/ Female and young) = 0.852]. Furthermore, the odds of male students agreeing to V3 is marginally higher (OR = 1.13; with a 95% confidence interval of (0.5, 2.6)), when compared with their female counterparts; and among the age groups, the mature students have a slightly higher odds of agreeing with V3 (OR = 1.31; with a 95% confidence interval of (0.6, 3)) when compared with the younger students. Putting these two views together, both the male and the mature and the female and young students doing mathematics believed to be stimulated when having classes organized according to courses. Such belief perceives that being among their peers could help them build their confidence about the learning of mathematics.

A learner could feel the experience of not integrating comfortably among a class of learners because of his/her age, thereby taking a position of not belonging to the class. This positioning of self within a discourse of not being part of a class of students would have impact on the learning of the subject, as the following experience of a participant of the in-depth interview showed. I asked Marr (age 50) to tell me about his experiences of learning mathematics at the University. He replied:

> …foundation year was difficult for me because immediately the other students see me as if I am a lecturer; you know I am 50; you know slightly grey. It was difficult for me as [a] mature student to integrate, and I felt a little bit stigmatized … I go home and think that I am going to be ostracized; it is tough you know, I felt nervous, being [a] student in my age and to make friends and ask them can I have help? You know when I do ask for help, they are going to say that old guy he can't keep up so…
> (Marr, White, Male, Biomedical Sciences, in-depth interview)

It is evident that Marr's age had played a significant role in limiting his integration with his younger class mates. He wondered whether he would be ostracized and had felt stigmatized, nervous and helpless; thereby creating an environment not suitable for him to fully participate in the mathematics module that he had to do (Evans, 2000). Solomon (2006) looking at first year students doing mathematics found out how some of the students positioned themselves 'as outside of the mathematics community' (see Section 2.5). As described earlier in Section 2.2, taking a poststructuralist approach help understand the discourse that positioned Marr outside of the mathematics community; and the discourse that relates the learning of mathematics to age. The discourse on age and discursive practices often spoken, as constructed by Marr, ‘You know when I do ask for help; they are going to say that old guy he can’t keep up’ limited Marr's participation.

From the responses of the respondents it could be inferred that classes that combined or brought together students following different main/principal disciplines, for the sake of saving running cost or for any other reasons, did not help their learning of mathematics; and the learners believed that catering each course according to its merit helps their learning of mathematics. A learning environment that allows for V3 would foster full participation in the class activities like answering and asking questions, sharing techniques of solving mathematical problems and experiences. That is, students are positioned to collaborate with other students from the same course or gender, ethnicity, etc. in order to develop their identity of engagement through communities of practices.

Some of the participants also thought that the pace of the lectures should take into account the variety of learning styles (Gurian, 2002; Francis and Skelton, 2005) and allow time for assimilation. According to the participants, pedagogy short of this would make the learning of mathematics challenging. For example Martha thought the teaching pace ‘was too fast’ for her and she explained how her learning took place by saying:

> …right now when I think of maths I get stressed because it is completely a different language to me and I can’t do it …yea just to me it [mathematics] is a different language if you explain more an equation on a board then I will copy it then I have to go home and look at [it] to understand what it says… the teaching pace was too fast for me
> (Martha, White, Female, Biomedical Science, in-depth interview).

Martha spent much of her time copying from the board with little or no emphasis on understanding or performing mathematical routines. Her perception of mathematics as a language was shared by another participant who was a mathematics specialist and member of focus group A. He said, ‘I see maths as a second language, and if everybody learns how to speak it the next thing you have to do is how you put things together' (Alan, Nigerian, Male, Mathematical Sciences, Group A).

The positioning of mathematics as a language, by interviewees Martha and Alan, implied the need for a unique method to learn it, and one of the best ways for learning a language is to 'talk' it (Sousa, 2008). Mathematics discourse speaks of distinct type of tools, words and visual means it uses and the 'endorsed narratives and routines it follows' (Sfard, 2008). In this sense, learners have to familiarize themselves with this new language to get the most out of it. Lee (2006: 1) points out that for the effective learning of mathematics, learners need to 'talk about their mathematical ideas, negotiate meanings, discuss ideas and strategies and make mathematical language their own'. Hence the learning of mathematics entails both the interpretation of mathematical symbols and signs and the construction of mathematical meanings that could be articulated and communicated to others. Martha's perception of mathematics as a language made the learning difficult for her. Positioning mathematics as a language, among other things, requires learning its vocabularies, syntax, rules, signs and symbols. Martha, in an effort to make sense out of the mathematics she was taught, had to spend more time copying and when she got home attempted to understand what had been presented. In other words, Martha's perception of mathematics as a language, as pointed out by Fuson, *et al*. (2005) was equivalent to perceiving it as a collection of rules that needed to be learnt and applied. However for Martha there was no favorable environment made available to her during the fast-paced lecture to talk mathematics. This then posed an additional problem for her by competing for time with her social roles as a mother of two young children, as a part-time worker and as a wife. Once again, Martha's view about the pace of the lecture (V4) is in agreement with the result from the quantitative analysis (see Figure 5.1, p.96) where 76% of the respondents agreed that a lecture that works at the learner's pace stimulates their learning. As pointed out earlier, the female students are nearly twice more likely than the male students to agree with V4 (Table A4.19, p.266). This indicates that students like Martha may be seeking a pedagogy that allows time for the learners to share their knowledge among themselves in order to enhance the learning of mathematics (Fayowski and MacMillan, 2008; Solomon, *et al.*, 2011). Simon speaking of the pace of the lectures and his learning experiences at the university said:

> …but for me the way the teachers usually taught, the fact that it's been taught at [a] fast pace and it is too much going on and on, makes it [mathematics] impossible for me to put into place all that at one moment… I know if I had more time I could do it, because usually I do not have the time to learn and it then becomes [a] nuisance. (Simon, Nigerian, Male, Finance and Banking, in-depth interview).

For Simon it was not only the pace of the teaching but the volume of the content covered week to week that proved to be problematic. Simon had positioned himself as having 'not-enough-time' to do his learning, yet he confirmed that he was not in employment and when I probed as to why his academic performance was not as he wished, he attributed his lack of time mainly to his 'laziness'. He later admitted this, 'I was too lazy to put in the effort to learn the formulas and all these different things'. Burke (2007:422) studied 38 men taking Access and Foundation programme at three Further Education colleges and one university. Burke examined their accounts of shifting masculine identities and noted that:

> ...a key theme in the men's talk is a natural tendency towards laziness and disorganization. Laziness is discursively constructed as an essential male characteristic which poses the most significant threat to their education and achievement past and present.

Simon's construction of his educational behavior echoes findings from Burke's research. Nevertheless, Simon wanted to ask questions until he understood the lecture but he could not practise this in the lecture as described below:

> …in a session there might [be], like ten things I don't understand, but the first two things I might ask the teacher and by the time it gets

> to the third and the fourth I feel embarrassed but it is like I don't want to bother the teacher asking ten questions, stopping the class. It really puts me off to ask questions.

The apprehension and fear of mathematics create a 'learned helplessness' (Dweck, 1986) attitude towards mathematics and makes students dependent learners on those students they consider to be better in the subject. The 'learned helplessness' in mathematics discourse attributes failure in mathematics to the lack of ability and students learn to give up. Simon realised that his points of difficulty could not be immediately addressed and he found himself in a similar predicament due to the feeling of embarrassment; he refrained from asking questions that could help his learning. Again, Simon was calling for a pedagogy that used a mixture of methods of delivery of a subject with ample time given to the learner to interrogate knowledge. Interpolating from the story presented above, one can see that Simon's engagement with learning during the lecture stopped after asking a couple of questions as he felt embarrassed to carry on asking the teacher for clarification of his 'ten things'. Consequently, he considered mathematics to be a nuisance and had no desire to learn it, except for the fact that it was a core module. For effective teaching and learning, the pedagogy needs to encourage engagement by accommodating the level of difficulty that some learners exhibit and the general level of interest of the learners in the subject (Pritchard, 2005; Boaler, 2009; Webb, 2011). Hoyles, (2010) and Lawson, (2010) confirm that having extra one-to-one assistance provided in the seminars/workshops enhance learning. In line with this, the quantitative analysis (see Figure 5.1, p.96) shows 70% of the respondents agreed that *having extra assistance (such as a tutor) available stimulates the learning of mathematics* (V8). In particular, the male students were twice more likely than the female counterparts to agree with V8 (Table A4.23, p.269).

Another learning strategy widely supported by 90% of the respondents is V1 (18. *Worked examples with exercises to solve help stimulate my mathematics learning)*. The responses of agreement with V1 among the two age groups are 87% and 92% for the young and mature students respectively; and the estimated odds of mature students in favour of V1 when compared with their young counterparts is 1.3 with a 95% confidence interval of (0.4, 4.5) (Table A4.16, p.264). Similar statistics for the gender groups are 86% and 94% of agreement for the male and female students respectively while the odds of female students in favour of V1 is a little more than twice, 2.13, (with a 95% confidence interval of (0.6, 7.6)) when compared with their male counterparts. The 95% confidence intervals for both the odds ratios include 1.0 showing a lack of strong impact of age or gender on the responses to V1. Similar conclusion is reached by looking at estimates of the conditional probabilities obtainable from using the fitted Logistic Regression model (Table A4.16, p.264); for example, P(Agreeing to V1/ young and Female) = 0.959 and P(Agreeing to V1/mature and Male) = 0.932 which are similar. Note that the students, irrespective of their age and gender, preferred a structured mathematics learning environment and a pedagogy that provided not only worked examples but exercises to be solved during their self-managed personal study time. It is a possibility that these learners did not want to be rushed, and preferred to learn at their own pace by consulting the worked examples while solving the exercises. As pointed out in Section 2.6, research (for example, Banks, 1993; Becker, 1995; Boaler, 1997; 2002) shows that female learners preferred pedagogy with a holistic approach that allows understanding of the concept. In line with the discourse of mathematics learning, one way of achieving understanding the concepts in mathematics is to work on mathematical exercises and problems. As presented in the previous chapters, based on their experiences participants of the interviews (see Section 5.2) also showed their preference to be a pedagogy that accommodates V1.

Maya spoke of the difficulty she had doing a mathematics module without first doing the earlier prerequisite module:

> The pace wasn't to my liking and it was fast for me as I did not have the basic prerequisite knowledge. But my peers… they loved it and the pace also suited them and I was the only one complaining and my level of confidence in QM was very, very low... I spent a lot more time on QM than on my other three modules because it was the one that I found more difficult and feared to fail it. With my other modules I have some knowledge in me but with QM I had nothing (Maya, Female, Bangladeshi, Accounting and Finance, in-depth interview).

Although the pace of the lecture was too fast for her, she had observed that it was not a problem for her peers. She had positioned her peers as having no problem while she positioned herself as having a problem. She was haunted by the fear of failing the module (Singh, *et al*., 2002) and, drawing on a deficit discourse (which blames the learner for the low performance/achievement and attributes the blame of failure on the lack of ability of the learners) it could be said that she believed her difficulty in the module was due to her lack of not having the prerequisite knowledge. Arguably, students like Maya could be better supported in their learning had they been identified at the recruiting stage to the course. Thomas (2002) looked at widening participation and student retention in Higher Education and identified a wide range of interacting personal and social attributes as well as institutional practices that impact both retention and performance of non-traditional students. Thomas argues that the values and institutional practices, for example, in terms of commitment to provide additional support, student representation, curricula and pedagogy, could improve the retention and success of students.

Considering the result from the quantitative analysis, an alternative route would be for the students themselves to seek assistance at an early stage in order to overcome the learning difficulties they will face. V6 (27. *Seeking assistance at an early age is effective strategy* *for learning mathematics*) is the variable related to such a strategy of learning. The quantitative analysis shows that 82% of the respondents (36% and 46% male and female respectively) agreed with. Examining the responses to V6 more closely, the Logistic Regression analysis (see Table A4.21, p.267) provides the estimated conditional probabilities; for example, P (Agreeing with V6/ Female and younger student) = 0.9931 while P (Agreeing with V6/ Male and mature) = 0.8103; the female and the younger respondents are highly likely to agree with V6 (estimated OR=8.14; with 95% confidence interval of (1.8, 37.9)) when compared with their counterpart the male and the mature respondents. Again this shows that these particular types of students want to take steps that enhance their learning of mathematics in the form of seeking help as early as possible during the learning process. This might be due to the differences in the level of confidence that female and male respondents come with when joining the module or the organizational and study skills experienced by the female respondents, or it might be easier for female students to come to the open in search of help. The investigation by Leathwood and Read (2009: 150-1) noted that:

> …lack of confidence is centered on the students' perceived lack of knowledge […] and lack of confidence are arguably harder to articulate for men than women due to the connection between outward confidence and culturally appropriate constructions of masculinity.

Maya's experience illustrated that the learning of mathematics is hierarchical (Goldin, 2008) where a prerequisite knowledge is required before doing the next mathematical topic and deficiency at any one stage of the learning will affect the overall learning (Boaler, 2009). That is, students will benefit from being introduced to the mathematical tools that will assist their learning and eventually make them feel confident.

The final theme related to pedagogy that emerged from the discussion was the experiences surrounding the actions taken or failed to have been taken by teachers while teaching mathematics.

5.2.3 Teachers' actions

Many of the interviewees discussed the importance of teachers in enhancing – or constraining their learning of mathematics. Some of them praised 'good' teachers for the path they had laid in front of their learners to journey to their imagined future of being mathematicians; while others blamed their teachers for the present problem they are experiencing in learning mathematics on deficiencies in their past basic mathematical knowledge.

Ed, a mathematics specialist and himself an assistant part-time mathematics teacher, remembered how the teaching method used by his mathematics teacher became a cause for his classmates to behave badly, subsequently 'killing' his interest in the subject:

> When I was [in the] 8th year level we had a guy [a teacher] from a special school… whatever, he couldn't express himself well… so at the same time the students started to be a little bit rude in the class. So it went all to kill our interest in the subject. After that I had to go all over from the start trying to build my maths and like I said because I was lacking fundamentals, it is like I was always struggling with it… (Ed, Nigerian, Male, Mathematical Sciences, in-depth interview).

From this narrative it can be inferred that, over a period of time, some teachers could be one of the causes for creating disinterest in learners about a subject taught ('to kill our interest in the subject'); but by taking an appropriate measure Ed was able to reverse the damage. Of course, this requires interest in the subject one is learning and seeing the significance of the subject in the future plan. For Ed, mathematics was essential to his imagined career since he has constructed his identity (Shaw, 1995) as a future mathematician. He is greatly affiliated with the subject and motivated to study it. He did not want to have a gap in his mathematics knowledge and he ‘had to go all over from the start trying to build’ his mathematics knowledge so that he could attain his imagined future. This is a view held widely among the respondents where the survey data shows that 89% agreed that understanding basic concepts is one of the strategies to be effective for the learning of mathematics (Table A4.6, p.234). Mario, another mathematics specialist, had a mixed experience of the behavior of his teachers while he was at school:

> I just got the impression that they didn’t want to teach us [the kids] and they were tired of us when we ask questions they were like, ‘Ah, I can’t bother to answer so and so’, it [my experience] wasn’t great (Mario, White, Male, Mathematics, in-depth interview).

Mario had constructed his teachers not wanting to teach them but he was not put off from enjoying the pleasure of solving mathematical problems and its challenges, as he described below:

> ... my favourite teacher… he would always say to me, ‘Ok, let me see if you could do something harder’ and he would bring me more work … and if I’ve done everything perfectly and very quickly and [there was] still more time to go he would bring me work that was even more difficult… start moving me to A-level work so he pushed me to keep going … But the rest of my teachers were nothing like that.

The role played by his teacher helped Mario develop his mathematical potential (Rosenthal, 2002; Solomon, *et al*., 2011) and underpins his position to continue and focus on mathematics, as the following quote about his view on the pedagogy, at the university, shows:

> …the maths modules here are taught pretty well…but [they] take a lot of work, and unfortunately if you do not have much time, then it can put a strain on you... Generally, I think I am learning a lot but it is just a matter of just focusing on the subject… the material that we were given were more than adequate… they were very good.

Mario seemed to speak from a position of strength and authority about mathematics and how to learn it. Drawing on his experience of learning mathematics, he could single out what is required to be successful in the learning of mathematics, which he said is to be ‘focused and to devote much study time’. He reached this position of strength in the subject by putting in a lot of work, but he cautioned learners that if sufficient time was not dedicated to the learning of mathematics there will be a strain on learners. He was very satisfied on the way mathematics was taught in the university, showing that he was on his way to being a mathematician, his imagined future. He had developed the generally accepted attitude for the learning of mathematics; a lot of work, devoting much time and being focused (Smith, 2002; Cobb and Hodge, 2011). This agrees with the respondents of the survey where 80% agreed that working at mathematics and solving as many problems as possible is the effective strategy for the learning of mathematics (see Table A4.6, p.234).

The role of teachers was discussed in the focus groups and the participants were asked to discuss their experiences with respect to the teaching and learning of mathematics. Here are some of the views expressed by the participants:

> The problem is the teachers are less strict; the students do not do enough exercise; and the students are less focused (Vladimir, Vietnamese, Male, Finance and Banking, Group B).

When asked to elaborate, Vladimir said:

> If you have a good teacher, hard work from the student [then] that is nice, but if the teacher is good and [there is] no hard working from students or no homework or exercise from [the] students, it will be a waste of time. So it is the combination of these two that make a student better in mathematics.

Furthermore, the importance of meeting what learners perceived to be expected of them was emphasized by another participant, ‘You don’t understand a subject by just having [an] extra class, unless you have [a] dedication to the subject’ (Annabel, White, Female, Finance and Banking, Group B). The views expressed by the two members of the focus group reinforce the sentiments expressed by Mario (in-depth interview above) who identified the key conditions he felt were necessary to succeed in the learning of mathematics. A good pedagogy alone will not make the learning profitable, but learners must also show dedication, commitment and exert much effort in the learning of mathematics. On such responsibility, as shown in the survey (see Figure 5.1, p.96), 84% of the respondents agreed the *regular attendance of classes by learners is an effective strategy for the learning of mathematics* (V7); this strategy is within the reach of the learners. One of the problems that hamper learning is absenteeism and improving school attendance has been a crucial part of the government's 'multi-agency agenda' (Whitney, 2008). It is possible that younger students joining universities might see skipping classes as normal since they might have been doing it while they were in schools. The views of the respondents to V7 adhered to the following pattern. Among the gender and age groups respectively, both the female and the younger respondents are more likely to agree with V7 as a strategy for learning mathematics (estimated OR= 1.9 with 95% confidence interval (0.6, 5.6) and 2.9 with 95% confidence interval of (0.8, 10.8) respectively) when compared with their counterparts male and mature students (Table A4.21, p.267). This might show that the female respondents had realized the hierarchical nature of mathematics learning (Reid, *et al*., 1981; Croft, 2002; Brown, 2003) and were unwilling to disrupt their learning by not attending classes on a regular basis. Similarly, the younger students, with estimated OR more than the mature students', might be aware of the importance of attending classes on a regular basis to succeed in mathematics and head-off early attrition.

Another experience shared by one of the participants of the focus group showed how a student's confidence of learning mathematics could be affected by the actions of a teacher:

> I really didn't enjoy maths at all in school, in primary school and secondary school; I think it was a mixture of feeling of being unconfident in it. Because, I think I had a couple of years that I did not learn maths properly at all from a teacher who again wasn‘t quite

> seem to be on the ball. And because I lost my confidence in maths
> from that period of time, I think, I find the rest of it extremely difficult;
> I had a teacher who literally did not care for maths and I did not learn
> for two years (Donald, White, Male, Biomedical Sciences, Group A).

Donald was obviously put off mathematics and believed this was caused by the teacher whose action made him lose his confidence and interest in the subject. As a result, this created discrepancies in his basic mathematical knowledge that he would have gained at secondary school level. Donald might have been justified to put the blame of the difficulty he encountered in the learning of mathematics on the seemingly unprofessional action of the teacher. Teachers are generally expected to demonstrate enthusiasm for the subject they teach, otherwise their action will not only damage the learning but it will kill the interest of the learners, which is vital for learning (Schoenfeld, 1992).

Rao, a mathematics specialist remembered how the view of a lecturer about a mathematics module he was doing created within him a negative image of the module and influenced the views of the other students doing that module:

> …the lecturer said this [particular mathematics] module is hard; so
> everybody in the room thought [it to be] hard; so we all agreed this
> [the module] will be hard…; everyone accepted this will be [a]
> hard subject therefore; nobody did that well as [with] other subjects.
> Well, if someone said, ‘Yes this is alright, it will get a little challenging
> but you’ll be able to do it’…the result would have been different
> (Rao, White, Male, Mathematics, in-depth interview).

Rao’s story indicated how his classmates developed a negative attitude towards achieving good result in this particular module. As pointed out in the literature review, students with positive attitudes and beliefs about what they were learning achieved more than students with negative attitudes (Zan, 2000; Mason, 2003; Mulat and Aravi, 2009). In addition, research suggests that the achievements of students are affected by the expectations that teachers have about their students (Rosenthal, 2002).

Marr, a non-specialist added:

> My experience after having learnt say, from yourself and some other doctors, the system they are teaching was like … I have absolutely no idea [what] the guy's talking about; I know, I will never, I don't perceive, I couldn't learn it [mathematics](Marr, Australian, Male, Biomedical Sciences, in-depth interview).

Marr positioned himself as someone never learning mathematics, due to the style in which it was taught and the terms used by the lecturers. Discourses about mathematics present it as a subject different from other subjects as it has its own rules, symbols, etc., and it is made distinct by the words it uses (Sfard, 2008). It is obvious that students feel uncomfortable, threatened and isolated when unfamiliar terms are used. One can imagine how the combination of not knowing the words used with the mathematical knowledge to be conceptualized could cause obscurity in the learner's mind. Marr challenged the way the teaching is delivered and underscored how it is crucial for lecturers to use uncomplicated language in delivering the contents of mathematics and to attempt to be aware of the differing starting points of the learners.

I knew Faith from the workshop sessions I used to run for the QM module. She was a frequent user of these sessions and I purposely picked her to take part in my study. She told me that she joined the university through the widening participation programme. Faith, drawing on her experience of education, particularly of a different pedagogical environment from her home country, Bangladesh, thought the way the teachers managed their classes was different. That is, while she was at school she got the impression that the teachers were not strict in their handling of the classes and hence created an environment of uncertainty in her methods of learning. She said:

> ... in Bangladesh if you are given a formula to learn you will not be let out of class unless you know it properly, but here it is a bit lenient - if you do not finish your class work, you will be let

out (Faith, Bangladeshi, Female, Finance and Banking, in-depth interview).

According to Faith, teachers in her home country force learning and she expected the same practice to take place in schools here. However, what was on offer in schools in the UK was that of learning on a voluntary basis and learners are given the support they require from teachers. But, as viewed by Faith, students did not get enough support as students are let out of class without finishing the set class work, which was not part of Faith's past experience. The cultural discourse appeared to present a dilemma to her and created a clash with her accustomed learning style and she said '...I did not understand the system and how they teach maths ... I wished if I wouldn't do maths ...' Mismatches between Faith's expectations and expected pedagogical practices within her learning contexts were evident.

It is possible to see the significant role that cultural practice plays in learning, and in particular Faith's experience shows how a change in teaching techniques affected her own learning. It is one of the responsibilities of teachers to give clear instruction to learners as regards to the importance of keeping up to date in the learning process. Such instruction can not only encourage learners to be engaged in independent learning but could also establish the authority of the teacher in guiding the learning; this is the element of the pedagogy that Faith did not see practised in the classroom. A pedagogy that is not able to adjust to the cultural differences of learners could isolate some of the learners, thus making learning of mathematics difficult for some (Petty, 2006; McCombas and Miller, 2007).

As pointed out in the literature review, the teaching technique used to deliver a subject has an impact on the learner (Webb, 2011; Solomon, *et al*., 2011). The results from the survey data (Figure 5.1, p.96) show that 78% of the respondents agreed that the teaching technique employed stimulate the learning of mathematics (V5). This had been confirmed by both the female and the younger respondents, as the estimated odds ratio statistics show that the female and the younger respondents are more than twice as likely to agree with V5 (OR= 2.21 with 95% confidence interval of (0.5, 9.4) and OR=2.60 with 95% confidence interval of (0.5, 13.2)) respectively when compared with their counterparts (Table A4.20, p.267).

‘Teachers as agents’ (Davies, 1990) of enhancing learning could play a significant role in creating within the learners a feeling of being accepted in the classroom. One of the participants of the focus group experienced the feeling of being ‘stupid’, as accounted below:

> …from my experience, what slowed my learning of mathematics, because I never derive any pleasure from it. …if I did not understand something I really want to ask question. I may be asking a question and getting a reply back that made me feel more stupid. …The person who gave me that feeling was my teacher… I was not the best student but it doesn’t help when you are a teenager and you don’t have a particular confidence altogether anyway and your teacher knocks you because you don’t know something very basic
> (Liz, White, Female, Biomedical Sciences, Group A).

Liz’s experience confirmed how a teacher’s apparent inappropriate action in treating his/her students could affect not only the learning but could create a feeling of embarrassment and withdrawal from learning the subject when a learner already had a low self-esteem. The damage that results from a teacher’s action could take time to heal and as a result learners find it easy to associate the subject with embarrassment they had experienced in their life time.

On the other hand, the following participant gave credit to her teacher, who not only made her love mathematics, but the teacher’s passion about mathematics was transmitted and the student considered becoming a teacher herself:

> …and when I went to A-levels, that was when I got a teacher who really made me love the subject …My teacher from A-levels is still in touch with me…she was helping me while I was in college and she

> has a passion and wanted to pass [on] that passion. I think I have also got it and I cannot wait to become a teacher and be like her. I wanted to inspire maths into young children and they would come loving it (Harriet, White, Female, Mathematics, Group A).

The strong link established between the student and her teacher had influenced the student's decision. Harriet was preparing to do her PGCE after completing her first degree with the intention of becoming a primary school mathematics teacher.

5.3 Factor 2: The learner's attitudes towards mathematics learning

The main focus of the interview questions was around the attitudes and perception towards mathematics as a subject. The following themes emerged from the discussion: disengagement from mathematics; mathematics creating negative emotions; and confidence in mathematics. I explored the PCA Components that could be related to Attitude towards mathematics, labeled here as Factor 2.

Koballa (1988) defines attitude as a mental concept that depicts favourable or unfavourable feelings toward an object. Attitude as one of the affective variables (McLeod, 1992) includes perceptions about mathematics and self. Evans (2000) studying the factors affecting the learning of mathematics of adults suggested a relationship between affective[29] variables and mathematical thinking and performance in mathematics. He pointed out that the affective variables are 'considered to "intervene"' between the basic social[30] variables and the performance outcomes. Research show (for example, Zan , 2000; Mason, 2003; Mulat and Aravi, 2009) that learners need to have the right attitude to make the learning of mathematics effective. The learning strategy will be effective if the learners identify

[29] Affective variables are characterised in terms of 'beliefs, attitudes and emotion' and 'cover reactions across a spectrum from 'cold', stable beliefs to 'cool' attitudes, to 'hot'/intense more transitory emotions'... Evans pointed out that the affective variables that might be expected to influence thinking and performance in mathematics in older students and adults include 'mathematics anxiety; confidence; perceived usefulness/difficulty of mathematics; finding mathematics interesting and/or enjoyable' (Evans, 2000:44).

[30] The basic social variables are 'gender, social class, age and qualification in mathematics' (*ibid*: 55).

mathematics, with their ‘practiced-linked identity’, the term used by Nasir (2002), and acknowledge its expediency. This process would require students as pointed out by Sfard (1998) to be ‘doing and becoming’ and to develop their normative[31] identity as a ‘doer of mathematics’.

Component 2 of the PCA is conceptualised to relate to the construct of Attitude but the variables that load on Component 2 do not match the issues raised in the interviews. However some of the variables that load on Components 3 and 5 that are believed to be relevant to Factor 2 are considered here. They are:

28. The learner’s natural ability to do mathematics

30. The learner’s past experience of mathematics

29. *The learner’s attitude and motivation towards mathematics*

33. The learner’s self-confidence and belief regarding mathematics

1. *The learner's perception of mathematics as a difficult subject*

The percentage breakdown of the responses of the respondents regarding these variables is shown in Figure 5.2 (p.120) and the result of the survey is incorporated in the analyses of the interviews given below.

In the following analyses of the interviews I explore how the learners constructed their mathematics related attitudes and their impact on the learning of mathematics. The discussions on each theme are as follow.

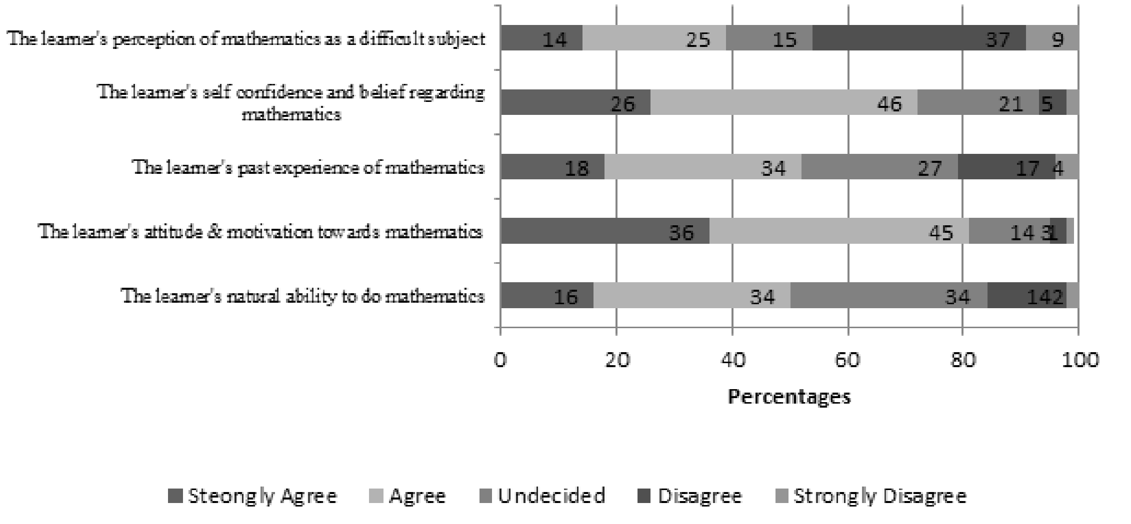
5.3.1 Disengagement from mathematics

Some of the interviewed students pointed out that there were times when they wanted to withdraw, avoid and metaphorically run away from mathematics. Some even went further,

[31] This concerns the identity of engagement with mathematics that the students would have to develop in order to become mathematical person as a doer of mathematics in their classroom (Cobb and Hodge, 2011: 188).

wishing to have a world free of mathematics and have nothing at all to do with it. Their experiences revealed that it was necessary to investigate the discourses that drove them to disengage from mathematics. One of such students was Simon.

Figure 5.2. Respondents' responses: In my opinion (perception), I think the following are important in affecting the successful learning of mathematics



Simon's response to the question of how mathematics was perceived by him and the people around him was:

> Everybody's perception is that mathematics is some complicated, out of the world subject… I guess if it was perceived like something that is easy, that would have been more easy for me to approach it positively rather than negatively like, it is difficult
> (Simon, Nigerian, Male, Finance and Banking, in-depth interviews).

The perception of mathematics as a complicated subject by the people close to Simon was one of the reasons that made him believe that mathematics was indeed difficult. As noted in the literature review, the perception of learners affects learning (Schoenfeld, 1992; Solomon, 2006) and the way Simon approached the subject, coupled with the view of himself as lazy (Section 5.2), made it easy for him to avoid mathematics altogether because it was negatively perceived, as being not easy. In order to find how he positioned himself with regards to other subjects, I asked Simon to compare the perception he has for other subjects with that of mathematics. He responded thus:

> I had enjoyable experiences for subjects like physical education (PE) and drama. … I was good at PE and I loved it; I was good at drama and I loved it; going to the secondary school, being good at mathematics but I did not love it when it got challenging; there was nothing to motivate me to put effort, putting works to understand more difficult concepts of mathematics. I did not love it like PE.

As described in Section 2.2, the discourse that has been active in positioning Simon not to love mathematics could be examined using a poststructuralist approach. The negative perception about mathematics that he had developed resulted from a dominant discourse of mathematics that speaks of mathematics requiring more understanding when compared with the subjects he fell in love with, PE and drama. What has been implied by the discourse made him to occupy the position of avoiding and not loving mathematics as it brought frustration to him, especially when new concepts were introduced. Since he had no love of the subject, it is likely that he had completely disengaged from mathematics (Smith, 2002). Such positioning of self will discourage learners to be doers of mathematics, hence affecting their identity of engagement with the subject (Nasir, 2002; Cobb and Hodge, 2011). His long-term association with mathematics was also affected by not having a defined goal for life. He explained himself for not having a goal by saying, 'I was young; I was not serious; I think that was natural not being serious when you are younger'. Nevertheless, the opportunity to develop his identity of engagement with mathematics had been affected at an early age and hence he found mathematics to be a nuisance and frustrating, which could be a justification for disengagement. However, the survey data showed 80% of the respondents agreed that working hard at it and solving as many problems as possible to be an effective strategy for learning mathematics (see Table A4.6, p.234). It appeared that Simon was unable to put into practice the strategy agreed by the majority of the respondents and this resulted in him distancing himself from mathematics, which led him to a complete disengagement from mathematics.

Carole sharing her experience of learning mathematics explained why she found the mathematics module she was doing difficult, '...but with mathematics it is [a] struggle overall. I was never confident in my ability because we often get, you know, lower mark[s] in the subject'. Probing as to why she used to 'get low marks' revealed that Carole contemplated an imagined future that could avoid mathematics, as she explained:

> ..I realise actually I know that I want to be a professional dancer;
> so I spent more time doing that because I know at the end of the day
> I'll probably be working on that profession, as it happens
> (Carole, White, Female, Biomedical Science, in-depth interview).

For Carole it was 'a struggle' with any topic in mathematics and she remembered the last time she did maths (many years back) and realised how detached she had become from the subject. From Carole's interview one can sense negativity about mathematics that made her question the reason for learning mathematics. Research suggests that learners with positive attitude are more likely to succeed (Mulat and Aravi, 2009) while those students with less positive attitudes towards mathematics and their capabilities did not (Zan, 2000; Mason, 2003). Here we see how Carole could not identify any relevance of mathematics in her imagined future and her life-long dream of becoming a professional dancer. It is likely that failure to match the purpose for learning mathematics with her future career had likely made her an uncommitted and unenthusiastic mathematics learner; and, as such, there was no evidence of a strong drive that motivated her to learn mathematics. After many years of practice as a professional dancer, she wanted to move to another career and Carole started a course in Biomedical Sciences, without being aware (she claimed) that a mathematics module was core for the course. At this point it is important to indicate that the majority of the Biomedical Sciences students who took part in the one-to-one interview claimed that they were not given appropriate advice on what is involved in their courses (see below). The survey result shows that 81% of the respondents agree that the learner's attitude and motivation towards mathematics affect the successful learning of mathematics.

The experiences of learning mathematics for Faith were not pleasant and she positioned mathematics to be 'not for her' and explains why:

> I wished if I wouldn't do maths ...because, everything I learnt I seem to forget it half way through. I practise in the tutorial and by the time I get home I cannot remember it. I do not blame anyone for this. It could be due to my other commitment [a single mother, carer and part-time worker] and maybe my mind is occupied. It is possible that this could be the reason [that] I forget the subject. Maybe it [mathematics] is not for me as a subject; but when I was a teenager I did not think this way
> (Faith, Bangladeshi, Female, Finance and Banking, in-depth interview).

Faith presented the reasons she believed had a significant contribution towards making mathematics a difficult subject to learn, having to disengage from it so that she could perform her role as a mother. The data from the questionnaire showed that a large percentage, 89%, of the respondents agreed that understanding basic mathematical concepts is an effective strategy for the learning of mathematics (see Table A4.6, p.234). I argue that any discrepancies in basic knowledge will make learners disengage from mathematics, as revealed by Faith's desire to withdraw from doing mathematics. Faith, in a panic measure, attempted to memorise (this strategy of learning was endorsed as an effective learning strategy by 63% of the respondents of the questionnaire; see Table A4.6, p.234) rather than assimilate knowledge from what she practised and by the time she got home she 'memory dumped' rather than retained and built coherent knowledge (Almeida, 2000). Faith's past position as regards to mathematics had shifted, and she no longer thought that mathematics was for her. Learners' identity can change depending on the situation they find themselves to be in (Bernstein, 2000; Mendick, 2002; Evans, 2002). Faith thought her age (‘when I was a teenager I did not think this way’) was the reason for the change of her identity regarding mathematics, but it may well be the challenge that mathematics offered her that made her disengage from it.

Elsa was asked to describe her experiences of learning mathematics and she began by saying how she enjoyed the mathematics taught at primary school level, and then how she took the position of ‘avoiding mathematics’ thereafter, going for courses that require very little mathematics:

> I need maths for what I do [referring to her retail business]. But it is basic and I am ok at this level; … But where I have to sit in class to learn maths, this is something I would totally avoid. I will not see myself going to take up a course I wanted [if it was] involving maths; it [mathematics] is not in my DNA... So my view on maths is... still a difficult subject. It can be enjoyable if you understand it, but if you don’t then it is not something you [‘ll] ever like
> (Elsa, Ghanaian, Female, Biomedical Sciences, in-depth interviews).

Elsa used a powerful metaphor of ‘not having mathematics in her DNA’, to point out that she felt that she was not born with a natural ability in mathematics. This view is consistent with other research results, for example, (Nobel, *et al*., 2001), which asserts that learners inherit a natural ability for the subject from their biological parents. The discourse of natural ability makes participants to believe that their ability to do mathematics is fixed, innate and dependent on their inherited ability. Elsa appeared to excuse herself from facing the challenges presented when learning mathematics. Nevertheless, she was capable of using mathematics for its utilitarian purposes in her retail business. She now sees herself disengaged, not belonging to or not to do anything with mathematics. She would have gone for anything except for mathematics. As she revealed to me at the end of the interview, she had wanted to do mathematics but lost interest when she was not allowed to progress to do a higher level mathematics due to her poor performance on the Foundation Mathematics tier at GCSE level. It can be said that Elsa did not develop her interest in mathematics and her understanding of the basic concepts was not beyond the GCSE level. She believed that mathematics was easy and enjoyable if understood. But, the position she has taken ('not having maths in her DNA') was undermining her confidence. This demonstrates the impact of the learner's attitude on the learning of mathematics. Marr also shared Elsa's view of positioning himself outside of mathematics and of positioning mathematics as being too 'clinical'. He said:

> …it's [maths] not for me no…maths is never the subject I enjoyed….
> when I was learning it, it was a dry subject it wasn't that I found
> something interesting…well it is very mathematical and clinical,
> isn't it? You know, one and one is two; it is not very easy sometimes; …
> I was a little bit bored of the subject; after a certain degree it gets quite
> difficult to understand, not knowing how to do it, you know
> (Marr, Australian, Male, Biomedical Sciences, in-depth interview).

According to Marr, the mathematical discourse of it being rigid by its nature had created an environment that forced him to disengage from it and position himself outside of mathematics, claiming that it was not for him as it was dry, not interesting, boring and difficult; views also supported by other learners (Schoenfeld, 1992). The focus groups also discussed how the learning of mathematics was perceived, and a participant pointed out:

> I never really hated maths; but I never had a big passion for it
> too. But in secondary school… I started losing interest and losing
> confidence in maths; and after that I did not do A-levels, and now I have
> started to go back into maths because I know I can't run away from it
> any longer. I have to learn it
> (Liz, White, Female, Biomedical Sciences, Group A).

Liz positioned herself as someone who was running away from mathematics, which demonstrated a complete avoidance and disengagement from mathematics; but when she later realized the importance of mathematics in her course she put in extra effort to try to learn it as if forcing herself back to the fold of mathematics learners; and hence she constructed a mathematical engagement identity of herself. This shows that mathematical engagement identities are not fixed as such and could be conceptualized as fluid, evolving as a result of new challenges faced by the learner. Other studies, for example, Anderson and Gold (2006) and McMullen and Abreu (2011), report similar experiences exhibited by learners.

5.3.2 Mathematics created negative emotion

Emotions as one of the variables that characterise affect can be considered as states of feelings that rapidly change and highly affective in nature (McLeod, 1992). Drawing on their experiences of learning mathematics, some participants remembered the times when they had negative feelings, frustrations, crying privately and feeling stupid and helpless because they could not do a mathematical problem or understood a mathematical concept. Such incidences could create negative attitudes and made the participants correlate mathematics with negative emotion. The learning of mathematics takes place within discursive practices (comments from teachers, peers, setting and tiered entry, etc.) and learning of it may not be free of emotion; and the learners are involved emotionally as described below.

Carole, who positioned herself as one of those learners who will never achieve in mathematics, shared her experiences as to why she positioned herself never achieving when she was younger. She said:

> Obviously, we need it [mathematics] in our everyday life; then when you are struggling with one of those top subjects we were told to be important at the GCSE level and you can't do it, then you feel that you are stupid. That's how I felt. I felt I couldn't achieve maths no matter how well I do in English, you know, I can do and get A*... but you know whatever matters, if I get As in other subjects, I was bothered that I couldn't do maths
> (Carole, White, Female, Biomedical Sciences, in-depth interview).

Her pre-university experience with the learning of mathematics may be summarized as not being able to do a subject that was positioned by the school discourse to be very important.

This positioning of mathematics as one of the two very important subjects had an effect on her feeling; the feeling of being stupid, helplessness and not achieving, and worrying and thinking that she could not do mathematics. The effect resulted from her experiences of learning mathematics at school level affected her learning of mathematics at university level. Carole narrated her experience of learning mathematics as first year university student and said:

> Because I got to a point where I realised that I was not naturally good in mathematics and I did try; ... but in the end I realised that I had other skills but I had to make sure not [of] leaving those subjects behind. Now I am actually in the university in the same predicament - still worrying about maths. I knew I was struggling in those areas... I have to sort of balance out where I spend my time studying because I am actually not doing a maths degree at the end of the day.

The natural ability discourse made its mark in making her believe in her inability to achieve in mathematics, a sense of being a failure. Carole took the position that she was not naturally good in mathematics, even though she spent time doing the mathematics homework. She rationalized, and took the position that she was not doing mathematics at a degree level and diverted her effort to the subjects for which she thought she had the required skills. She pondered, '...why should you have to be good in numbers, which is analytical, when you are on a job that uses no maths or a little bit for which you can employ someone else to do that work for you?' This question was said with an outpour of emotion to express the hurt and the feeling of worrying and struggling from her attempts to learn mathematics. Those students who join HE with gaps in their mathematical knowledge are at risk of struggling where a certain level of knowledge in mathematics is assumed (Sutherland and Dewhurst, 1999; Croft and Ward, 2001; and Sabin, 2002). The perception that Carole had about the value of mathematics was in direct disagreement with the majority of the respondents of the survey where 69% and 71% agreed that skills learned from mathematics could be related to the real world and important to daily activities respectively (see Table A4.6, p.234). Similar views to Carole's were expressed by Martha. When looking back at her experience of learning mathematics, Martha said:

> I understand it is a foundation of many very important things,
> but for me personally in my life, NO! [with a display of frustration].
> I don't know what maths is useful for; I don't know what is possible or
> impossible because of maths… Only for my primary project… only
> [that] you have to draw graphs… that is the only thing I can apply
> it [to]… but in my future, NO! For me, my life and for my job,
> [it is] NO!
> (Martha, White, Female, Biomedical Sciences, in-depth interview).

The utility discourse on mathematics puts mathematics to be useful in the day-to-day living, but, drawing on her experience, Martha positioned mathematics as not having anything to do with her life or her job. That she was unable to see the use of mathematics, anywhere, created within her a negative attitude towards mathematics. However, 71% of the respondents had the attitude and belief that the importance of learning mathematics was that 'the skills learnt could be used in day-to-day activities' (Table A4.6, p.234); but due to her perception of mathematics she could not see any useful application of it. In hindsight, Martha thought that she was never really equipped (with basic mathematical knowledge), and said, 'Yes it caused me; I mean have effect on me… My experiences were, well, I say why, why this [not to be able to do maths as her classmates were able to], I cry in my kitchen table'. This is indeed an emotion expressed to its fullness, an emotion directly generated from attempting to learn mathematics (Evans, 2000).

5.3.3 Confidence in mathematics

Evans (2000) pointed out that confidence is one of the affective variables that is expected to influence mathematics learning in adults. Tariq (2002:76) points out that one of the reasons for the perceived decline in numerical skills is 'individuals' lack of confidence, panic and fear of mathematics'. Most of the participants in the interviews who had imagined future as mathematicians or who could see the potential role of mathematics in their chosen area of studies had developed their confidence in the subject; while some non-specialists gave reasons why they did not have the confidence in the subject, as narrated below.

With the help of private tutoring available to her, Maya developed her confidence in mathematics. She had also developed her mathematical identity of engagement by becoming a doer of mathematics, as she explained:

> ... I really enjoyed my GSCE maths and that was only due to the fact that I had a private tuition at home and I understood better what I was doing. So that motivated me to learn more, and when I was in class I was giving the correct answers, and this further made me to do better and better
> (Maya, Bangladeshi, Female, Accounting and Finance, in-depth interview).

Maya was motivated and took part with confidence in class activities thus helping her develop her normative and core identities. She aimed to achieve a first in her degree classification. This goal of gaining a first class degree had acted as the unseen force within her to strengthen her commitment to the subjects she studied and enjoy her studies. Maya positioned herself as someone enjoying her studies because of the interest in mathematics she had developed when she was younger in agreement with the survey result where 71% of the respondents agreed that developing an interest in mathematics to be an effective strategy for the learning of mathematics (Table A4.6, p.234). The fact that she was able to problem-solve and give the correct answers helped her associate herself with mathematics and develop a positive attitude, which includes being a doer of mathematics.

Rao positioned himself as quite good in mathematics and positioned mathematics as one of the subjects he enjoyed. He said, '...probably it [mathematics] is an easy subject… it's easier and enjoyable. I guess I am quite good, but not as good as most people are' (Rao, White, Male, Mathematics, in-depth interview). Rao had developed his confidence in mathematics and considered himself as good at it. His perception of being good at mathematics is to be related with the ability to solve mathematical problems and get good results. When asked how he became ‘good’, he said that he did not know but thought that he had it within himself, inside him. Rao’s perception of becoming good in mathematics reflects the discourse of individuality that ability in mathematics is related to individual’s innate talent and effort rather than other factors.

Ed, another mathematics student, informed me that he was set to achieve highly in the subject and described how he took the steps he felt necessary to enable him to fulfill his target of achieving a high grade. Again, he took up an individual discourse of self-determination:

> I am really determined; I think far behind the level and like to see the results … I will say I try to put myself under a lot of discipline, but not pressure… concentrate on my weekends… and then so it is like one’s goal; I suppose to be positive; I am trying to push myself to achieve something good
> (Ed, Nigerian, Male, Mathematics, in-depth interview).

The determination and the willingness of Ed to be under an intensive discipline regime so that he could achieve a high mark agrees with the attitude and confidence that learners of mathematics need to have, as confirmed by the majority (72% - 81%) of the respondents of the survey data (see Figure 5.2, p. 120). Ed is an example of one of the many HE students considered by the ‘new subject of free-market neo-liberalism policy of discourse of the New Labour as an ‘independent, autonomous and self-directed individuals’[32] (Leathwood and O’Connell, 2003:599).

[32] An independent learner is constructed to be a student who takes responsibility for their own learning, aspire to greater things and develop their own potential; however the fact remains that the reduction of resources available to students has forced students to be independent learners.

Mario was fascinated by mathematics. He spoke of the subject metaphorically as a living thing or being that could be loved/ hated and could make a learner happy/ sad. Developing interest in the subject is held to be an effective strategy for learning mathematics by 71 % of the respondents of the survey (see Table A4.6, p.234). He described his association with mathematics as follows:

> There is no rest until I find out [the] answer that I am looking for. So because of that and the obvious passion I have for it; the way it holds me when I am using mathematics, the way it grips me [it] just it doesn't let go. So because it has [the] capability of both making me happy, keeping me focused and also making me very, very upset and angry that [is] all combined together [and] makes me love the subject (Mario, White, Male, Mathematics, in-depth interview).

As a potential mathematician (his core identity), Mario enjoyed the challenges that mathematics as a subject could bring and also the joy of solving mathematical problems. He enjoyed mathematics and spoke of the love for it in a romantic way, '…because of the obvious passion… I have for it; the way it holds me…, the way it grips me… just… it doesn't let go…'. His love with the subject developed over the years as his realization of the capability of mathematics as a subject in addressing scientific queries and generating numerous and new interesting theoretical challenges grew. Reflecting on his experience of his high school years, Mario constructed mathematics to be as the most important subject of all the subjects he had so far encountered because he got an explanation from mathematics to his queries of how things around him work. In accordance to the discourses of individuality, he described how he had taken measures to build up his confidence in mathematics. Learners who completely identify with mathematics and appreciate its 'beauty', to use Davies (1993) terminology, might find it easy to develop their confidence and attitude by putting in the required effort as doers and learners of mathematics. So hard work, developing an interest, understanding basic concepts and relating mathematics skills to the real world was the attitude Mario had towards effective strategies for learning mathematics in agreement with the views of the majority of the respondents of the survey (see Table A4.6, p. 234). Mario had developed his confidence in mathematics as it is his imagined area of profession.

The perception of mathematics was discussed in the focus groups and the experiences of some of the mathematics specialists are given below. A participant of the focus group A said:

> … I always look upon it [mathematics] to [being] better [than] other subjects and I have always got a good grade and I think it is something I like …I do not see it as difficult, but something that you have always to practise. That means, you have always to practise to remember what you were taught and said in class…. basically if you don't practise you cannot be better in mathematics
> (Alan, Nigerian, Male, Mathematics, Group A).

This participant constructed himself as a doer of mathematics and based on his experience he confirmed that a continuous practice in the subject could give confidence for learners to improve and succeed in mathematics. Likewise from his experience, he said that a lack of such attitude towards mathematics would result in finding the subject difficult and there would be no betterment in it. Another participant added, 'Maths is about practising and observing things and you can get results (Gamal, Egyptian, Male, Mathematics, Group A); another participant said, 'When you do it [it is] because it needs to be done, because people like that… they do excel in that course because it is their passion; otherwise they don't' (Harriet, White, Female, Mathematics, Group A). In order to develop the desired attitude of building confidence in mathematics, the focus group members highlighted the importance of working hard on it. This agrees with the respondents of the survey where 80% agreed that working hard at it and solving as many problems as possible to be an effective strategy for learning mathematics (Table A4.6, p. 234). Reflecting on his own experience of discontinuing doing mathematics, one participant pointed out the danger of inconsistency in one's practice of doing mathematics by saying:

> …so once you stop doing it for a bit, you can't… it is very difficult to move up the levels… once you haven't got the basics, then it is very, very difficult to continue and so that was my main issue with it. I had this gap and I had never resolved that (Donald, White, Male, Biomedical Sciences, Group A).

This is an experience supported by mathematical discourse that illustrates the effect of disengagement from mathematics, even temporarily, on the confidence of learning mathematics. One explanation of why some learners found mathematics difficult and challenging was given by one of the participants of the focus group B:

> …Probably they [some learners] don't see the point [of] why they are studying it. So they will see [look] at a formula and say, 'Where am I going to use it and why do I need to study it? I will never use it in my life… and so they do not attempt making maths applicable in practical life (Annabel, White, Female, Finance and Banking, Group B).

The participants of both focus groups drawing on their experiences and in line with discourses about mathematics clearly demonstrated the importance of having the right attitude and putting effort (in the form of continued practices) into understanding the basic concepts and relating skills gained from mathematics to the real world.

5.4 Summary

In this chapter, taking a poststructuralist approach I have identified discourses about mathematics which are taken up actively by the learners to position themselves in relation to mathematics and how they are positioned within these discourses. This is done by bringing together some of the findings from the qualitative and quantitative analyses that revolve around the various discourses related to Pedagogy (Factor 1) and the Attitude of learners towards mathematics (Factor 2). In line with the relevant discourses and their experiences of learning mathematics, the participants indicated the impact of discursive practices they had encountered while learning mathematics. In particular, for the non-specialists the allocated time for lectures and tutorials and the pace of the lecture were perceived to be problematic and compromised their learning; on the other hand as expected the specialists did not consider this to be a problem. Some of the interviewees pointed out that the time slots allocated for the lectures and tutorials or seminars do not meet the learning needs of a particular group of students, the mature non-specialists. Most of the non-specialist participants in the one-to-one interview believed that a short lecture followed by an appropriate length of seminar or tutorial session would give them the opportunity to construct and assimilate knowledge. The pace of the lectures that some of the students experienced in their mathematics classes was believed to be incompatible with their learning styles they had developed or with the level of their previous understanding. Some of the interviewees recalled the roles played by their pre-university teachers and how these slowed down/enhanced their learning of mathematics.

In addition, the participants pointed out how their attitudes towards mathematics had been affected by discourses in mathematics. Some of the participants, in particular the mathematics specialists who have positive attitude about mathematics and the learning of mathematics developed their mathematics-linked identity as doers of mathematics and becoming good in it. The non-specialists recalled how discourses about mathematics had created negative emotion within themselves, resulting in a loss of their confidence in the subject and disengaging them from learning mathematics. Some of the non-specialists wished to have their own academic world with no mathematics and the only reason for them to do a mathematics module was that it was a core module and they were obligated to do it. However, the participants of both focus groups agreed on the importance of having the right attitude to succeed in learning mathematics. Mathematics is viewed by the participants as a source of pleasure (by the specialists) and frustration (by non-specialists).

CHAPTER SIX

Second Set of Factors: Support, Belief and Perceptions

6.1 Introduction

In an effort to explore further about the factors that were believed to affect the learning of mathematics, I asked each participant of the interviews to share the experiences they have had when learning mathematics. This chapter presents the discussion about the impact on the learning of mathematics of the support given to learners (labelled as **Factor 3**), the beliefs about mathematics that learners have (labelled as **Factor 4**) and the perceptions about mathematics that learners and others, like parents and teachers, have (labelled as **Factor 5**). On the basis of a poststructuralist approach described in Section 2.2, I looked at the pattern of responses emanating from the qualitative and quantitative data and how discourses related to mathematics shaped the construction of the learning of mathematics and the factors believed to affect their learning.

6.2 Factor 3: Support

I explored the impact of support made available to learners on their learning of mathematics of the participants of the one-to-one in-depth interviews and the focus groups. Each participant of the interviews was asked to share his/her past experiences of learning mathematics in relation to a form of support available for them. The themes that emerged from the discussions were social support, reward and sanctions, and cultural background. Research for example, Francis and Skelton (2005), show that students who got support from social networks, relatives and family members did well in schools. In addition, the social capital, in the form of family support made available to learners, or cultural capital that provides motivation (Dumais, 2002) will help develop the confidence and belief of the learners (Presmeg, 2007). The only variable of Component 3 of the PCA (Table A4.6, p.234) that could be matched with the themes of Factor 3 is '31. *Support and encouragement of learning mathematics from the family is one of the important factors that affect the successful learning of mathematics'*. The respondents of the survey were asked for their views on the statement and the quantitative analysis shows that 48 % agreed with the statement while 31% of the respondents could not make up their mind about this statement and chose 'undecided'. The themes from the interviews are discussed below in detail.

6.2.1 Social support

The participants recalled the experiences of support, from their parents, friends, and close relations that enhanced or slowed their learning of mathematics. The experiences of support received by some of the participants, including the two particularly contrasting experiences of Carole and Rao, are presented below. In her interview, Carole discussed the level of family support given to her when she was younger:

> ....in terms of my parents, actually neither of them had education...
> My parents were not particularly pushy ... we all were told to do our homework. It was always the case [that] you try your hardest and make sure that you work hard. ... No complaints if you don't do maths....
> If the teachers put in effort and initiative that I would like, I'll try
> (Carole, White, Female, Biomedical Sciences, in-depth interview).

The social capital available to Carole in the form of family support was limited, and the additional support from outside the family in the form of private tutoring could not be purchased because finances were difficult. Carole's learning was dependent on the initiative of her teachers and limited interest towards learning mathematics. She talked about how she was 'put off' mathematics and had always found mathematics difficult: 'Looking back I wish I had a private tutor; that could have helped me and I would have not struggled in classes'. As pointed out in the literature review, this is one example where a social capital with inadequate resource, or the absence of it, will limit the type of support it offers (Bourdieu, 1984; 1997; Noyes, 2004). In contrast with Carole, as described below Rao had a different experience:

> I don't know, it is like, possibly, good foundation because my mother went to university …as well as my brother…but it is always the same like 'you really should do well because it's a much needed subject [mathematics]'
> (Rao, White, Male, Mathematics, in-depth interview).

Rao further explained the type of support he got from his family:

> …[my mother said] 'I have been doing this at university; sort of, I will show you how it's done', … and if I did have problem I ask my mum and she explains things, talk it through...

Rao acknowledged how his parents gave him a good foundation in mathematics, always reminding him of the position of mathematics in the academic world. Rao, as seen earlier in Chapter Five, enjoyed mathematics and I argue that the external factor, in the form of the social capital available to him through family support at home, made the difference for him to take a position as a member of a community who enjoys mathematics.

Maya, as presented in Chapter Five, used the social capital available to her in the form of family support through private tuition and developed her confidence in mathematics. She said, '... I really enjoyed my GSCE maths and that was only due to the fact that I had private tuition at home (Maya, Bangladeshi, Female, Accounting and Finance, in-depth interview). The support that a community, as a social capital, can offer was also acknowledged by Maya: '...I have got good people around me [members of her community] to help me and motivate me to continue my studies'.

Marr spoke of how the importance given to education held by his father helped him and his brothers perform well in school as described below:

> We [brothers] were pushed academically by my father and we were

> always told, since we were very young, about the value of education. He always made it clear; that's why he was expecting… we all did well at school; we scored very high pass marks
> (Marr, Australian, Male, Biomedical Sciences, in-depth interview).

The father not only made sure that his children understood the value of education but he was expecting that they performed well in school. However, availability of support alone will not enhance learning, since the willingness of the learners also matters, as the following participant explained:

> …nobody is interested in mathematics in my direct circle. My father was a businessman. He did well for himself, never having education, but he would say to me, 'Study, study; education is very important to get a good job', but I say to myself, 'He didn't do it [so why should I?]'. My father tried to convince my brothers and me to study; he offered to help, like hired tutors. None of us wanted it
> (Martha, White, Female, Biomedical Sciences, in-depth interview).

The father was talking within a mathematics discourse of 'practising in order to learn it'. However, although her father made available extra support for the kids he was not a role model to his children when it came to academic success. The kids could not relate what the father claimed education to be and his success as a businessman without having formal education. This was a major setback for Martha; she was unable to make use of the support available at her disposal. Other members of the focus group spoke of the contradicting roles that could be played by the family regarding the learner's performance in Mathematics. Ellen recalled her experience with feelings of frustration:

> I remember my father … making me sit and do maths with him. He would literally have me stand in front of him at seven/eight years-old, saying, 'What is this? What is that?' And that probably flinch me out somewhat, and I gone the other way. That was a horrendous experience and it was a panic and [I] was stressed by having a wire crossing into my head and I couldn't think when I was in that situation, blank. That was what it was like
> (Ellen, White, Female, Biomedical Sciences, Group A).

As could be seen from Ellen's experience support made available may influence what people do (Schunk, 2009). Her father was acting within the power relationships of father and child and employed a technique which he might have thought reinforce the learning of mathematics. As described by Ellen, her father had a strong assertive personality, 'his personality by the way was army-like'. However his technique did not help Ellen to learn her basic mathematics; rather she painted a mind picture of mathematics and was pushed to perceive that mathematics is rigid and difficult. In her own words, 'This is what I have said earlier, that my father was quite a bully on it [maths] and that sort of criticism will put [a] mental block on it… I have passed years of not knowing mathematics, so it was for me a subject I would avoid'. This surely is a negative scar left from a relationship of negative reinforcement by a significant 'other' from whom she naturally expected to gain support in aid of her learning. However, her father might have not meant to cause such hurt to his daughter, but the experience remained with Ellen for a long time. Fortunately, Ellen followed a route of action to overcome the effect of the negative reinforcement, as she recounted:

> ..when I want[ed] to come and do the course I am doing now, I knew that I had to do maths. I had to go on [a] Foundation Course to do maths and I got a kick out of it because I find it challenging, but I did quite well…. I was quite proud about myself actually. So in a way it really boosted my confidence.

As pointed out in the literature review, learners like Ellen with a positive attitude, a determination and willingness to learn are highly likely to succeed in their education (Mulat and Arcavi, 2009).

6.2.2 Reward and punishment to motivate the learning of mathematics

Participants were asked about their past experience of learning mathematics and this engendered interesting discussion around the use of rewards and sanctions to encourage the learning of mathematics. Experiences of participants regarding caning and other forms of rewards/sanctions are presented below. Marr reflected on how he was taught mathematics when he was at secondary school:

> I can remember one teacher… You know, he was a nice guy, but now and again he became violent; we used to have [an] exam on Monday mornings… He had a leather strap, because in those days they can beat you. He would beat you across your hand bent; one for every mistake that you got. Sometimes it causes you to bleed from the beating. The leather reaches your bone, thigh, hurts badly [*laughter*]. He was very ambitious; you feel terrified getting wrong obviously but I was never been beaten [*laughter*] (Marr, Australian, Male, Biomedical Sciences, in-depth interview).

When asked if this method of teaching helped him learn mathematics, he emphatically replied:

> No! [It] definitely, did not help me. The man was making me learn out of fear without understanding, you know. No! He did not sit down and explain to me where I was going wrong; you couldn't feel you can approach him for that. There was no extra class like after school coming to him saying I am not getting this question.

This is an example of a pedagogy based on negative reward. Literature (for example see Infante, 2005: 194) clearly confirms that negative reward (punishment) can be destructive and produce negative effect. As Marr pointed out an attempt to push knowledge through learners' head is impossible; instead a proper explanation of the topics is what is expected of a good teacher (Korthagen, 2004).

On the one hand, members of the focus group B thought that sanctions had a positive effect on learning. While discussing the behavior of some of the teachers the participants had in their educational experiences, some of them revealed that they were caned when they were at school. I then posed the question 'is punishing pupils (like caning, etc.) acceptable in the present age'? The response given was:

> … yes, of course. It will help a lot, because if they [the teachers] want you to be the best and you are also trying to do your best in a way and then if they are punishing you, even if it is funny [*laughter*], you need to do something to prove it that you are getting it… although

> humiliated in front of everyone. You want to have good results and other people will be proud of you, especially when you are a child (Annabel, White, Female, Finance and Banking, Group B).

This is a view that focuses on the outcome (the end justifies the means), rather than on the wellbeing and the right of the learner child. Such views were acceptable in some cultures only few decades back (Annabel comes from Eastern Europe) while in the UK it is illegal (Bitensky, 2006). Unlike Marr, as far as Annabel was concerned, such practice did not bother her as she had related it to her success and she would support it. However Marr's account indicates that there could be some mature students who experienced some sort of sanctions in their past life; such experience could have shaped their perception of mathematics and correlate mathematics to the caning they received previously; thus making them hate, avoid and think of mathematics as a hard and difficult subject. Gamal remembered how his father would have him sit at the table to dine with him and give him money as a reward for showing progress in his mathematics, as presented below:

> …my father used to train me to become a new boss and take over his business. So I used to stick numbers on the labels and count;… he says you have to do well and whenever I excel he used to give me money, like sitting on his table [to dine with him], doing his finances … and if I excel, basically I get a reward
> (Gamal, Egyptian, Male, Mathematics, Group A).

Gamal was engaged in mathematical activities because he had believed he would be rewarded by his father. The reward from the father may have helped Gamal not only to love mathematics (if he had not already loved it) but to choose to study it at a degree level for his imagined future career.

6.2.3 Cultural background[33]

As pointed out in the literature review the cultural background of learners plays a significant role in their learning (Bourdieu, 1984; 1997; Bourdieu and Wacquant, 1992).

[33] In this thesis the tradition, norms, values and everyday practices of particular societies and social groups form the cultural background of a learner.

The experiences of the participants as recalled by the interviewees showed how their cultural background affected their learning. The impact of the background culture of the learner was one of the dilemmas faced by these mathematics learners as they moved between different cultural contexts. Gore said:

> …I think the way we perceive higher education is completely different. For example, the way people take education in Africa and the way people take education in Europe is totally different. I do not know about other countries in Africa, but in my country you are praised for being the best... but if you try to be the best here, ah my word, oh it is a flip on its head (Gore, Nigerian, Male, Finance and Banking, Group B).

This observation goes deeper into querying the essence and value given to higher education in the Western World. Higher education in the West, the participant seemed to say, is something you do as an extra activity, but not as a necessity. In some cultures, personal development hinges around higher education, to the extent that people try to be the best and their effort is positively acknowledged through praise; a similar effort here in the West may not be valued at the same level of appreciation by classroom peer groups. Similar discursive practices that could arise from differing cultural views are thought to cause the differences in value given to higher education by the West and other cultures. A similar view was expressed by other participants. For instance, Ed, who was schooled in Nigeria and one of the participants in the one-to-one interview said:

> I was an ordinary student and I don't come from [a] very rich family. My parents knew the value of education, so we had a teacher coming to teach us at home privately, because those were the days... those who know the value of education do all what they can to help their children (Ed, Nigerian, Male, Mathematics, in-depth interview).

According to Ed, it has been a cultural norm until his arrival to the UK that a person from their region with no academic qualification would have a limited success in life, which is contrary to what is experienced in the West where one shouldn't necessarily have a higher academic qualification to be successful. Based on their observations, Gore and Ed believed that higher education is not valued as a priority to [a] majority of the learners here in the West, and the value given to education is bound to affect the commitment of the learners to mathematics at various levels. Contrasting the education system here with the system his parents experienced in their native country, Nigeria, Simon added:

> I think from young age, the system [here in the UK is] allowing us to be as kids …if I've got thinking, if I fail nothing will happen to me, then why do I need [to put] effort? I will not put effort if nothing is happening to me. That's how I always felt when I was younger… the system encourages pupils to be much more laid back…but my parents were told that they had to learn maths …there was no choice or option (Simon, Nigerian, Male, Finance and Banking, in-depth interview).

This is an example of a dominant discourse about the value of mathematics that is passed from generation to generation. As experienced by the participants, dominant discourse within the family and schooling practices and cultural background had shaped their perceptions of mathematics. Mario described an experience where the social and cultural capitals strengthened his love of mathematics and his study of it said:

> …my mother insisted on sending me to a private tutor who was very good; my parents supported me a lot and they were pushing me to do well. So that is the way my parents raised me to understand that the real world is not all fun and games. They have to teach me that from very, very young age... I am thankful for that and very, very happy that they did that because it prepared me for where I am now… I was raised being told to do my studies always before anything else (Mario, White, Male, Mathematics, in-depth interview).

This is yet another example where the ethos is laid down by an older generation (parents in this case) for the offspring to adhere to, and this ethos bears fruit. I argue that the cultural heritage of the family coupled with strong reinforcement from the family contributed towards Mario's appreciation for mathematics and his confidence in it.

6.3 Factor 4: Learners' beliefs about mathematics

The participants in the interviews were asked to explain their beliefs about their perceived value of mathematics. The participants, talking within discourses about mathematics expressed views that emerged as themes around the utility of mathematics for jobs, for professions and the sciences. Belief, as one of the variables that characterise affective (a wide range of feelings and moods) can serve both cognitive and affective functions (McLeod, 1992; Evans, 2000:43). Beliefs are mainly cognitive in nature and they are developed (socially constructed) over a long period of time. In this thesis, based on the framework of post-structuralism, belief is considered to be the notion of ‘cold’ stable feeling (Evans, 2000:44) that could be accessed by research. A learner’s belief about mathematics and themselves has some bearing on the attitude of his/her learning of the subject and influences their understanding (McLeod, 1992; Evans, 2000). Research has identified the importance of individuals’ beliefs about how they learn and their beliefs about the nature and validation of knowledge claims within the discipline (Boaler and Greeno, 2000; Furinghetti, 2000). The consistency between belief and attitude could help the learner act effectively in support of the learning of the subject (Schoenfeld, 1985; Evans, 2000). The following five statements (variables) of the questionnaire as identified from the PCA were among the variables used to construct Components 2, 4 and 5 which are conceptualised as the attitudes, beliefs and perceptions of the respondents about the perceived value of mathematics as a subject and the learning of mathematics. As pointed out in Chapter Four, sometimes the distinction between some of the Components is not very distinctive; for example, a variable could be viewed as being related to attitude or belief. The five variables that I believed could be used to deal with beliefs are:

8. *Learning mathematics is important because I use the skills I learn in my day to day activities*
9. *Studying mathematics stimulates my thinking, creativity and abstraction*
10. *Studying mathematics will make me more employable and help in my career (*V9)

11. Achieving C or a better grade in GCSE/A-levels mathematics should be a general entry requirement into universities

14. The importance given to mathematics in society is over stated ***(****V10****)***

The breakdown of the percentages of the responses is given in Figure 6.1 below.

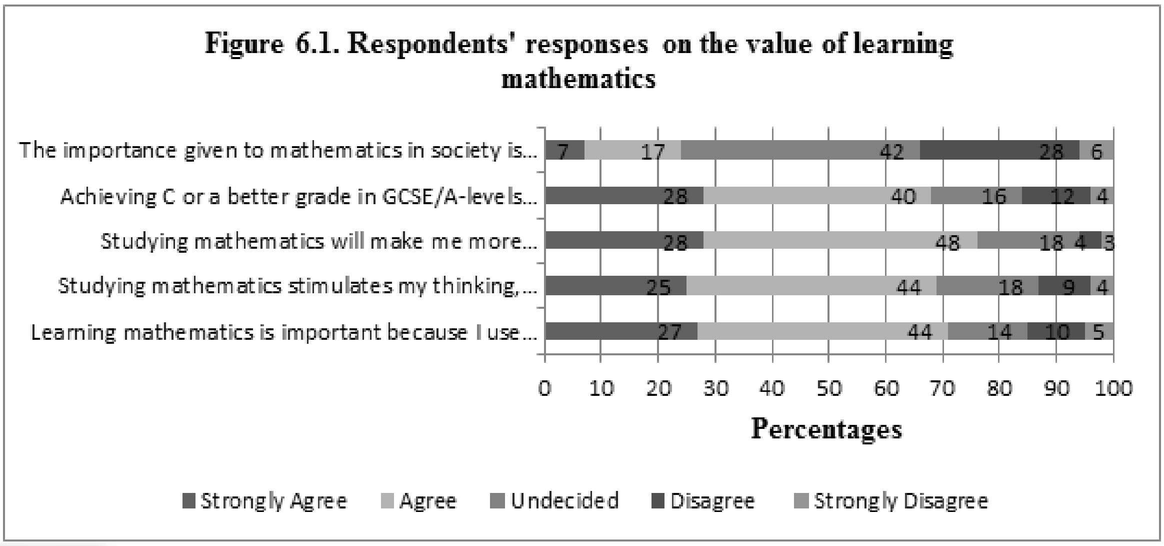


Figure 6.1. Respondents' responses on the value of learning mathematics

Note that from the factor analysis on the questions related to the values and perception of mathematics (categories I and II, see Appendix 3, p.218) the Component conceptualised as belief was extracted from the first four variables. Figure 6.1 shows that only 24% agreed with the first variable ‘the importance given to mathematics in society as being over stated’ (note that 42% of the respondents were undecided); while the majority of the respondents (68% - 76%) agreed with the values ascribed to mathematics in the remaining four variables. The themes of Factor 4 are discussed in detail.

6.3.1 Mathematics believed to be essential for jobs

Simon recalled what had been said about mathematics when he was at primary school:

…from young, for the academic life the message has been

> you need this [mathematics] to pass. But now I realize that I need it for life skills. When I look at a certain job descriptions they are talking about ability to read formulas and all those mathematical terms. Now I am thinking, 'Wow, we do need it for life skills!' That's what it got me more motivated in terms of improving my mathematics
> (Simon, Nigerian, Male, Finance and Banking, in-depth interview).

The discourse about the importance of mathematics to advance in academic work and gain skills that are important for jobs seemed to be central to Simon's belief about mathematics both as a must-pass subject and offering a life-long skill required for jobs. It could be said that what helped Simon perform to the required level and work hard is the belief that he had about the life-long skills gained from the learning of mathematics. Maya's comments agreed with Simon's and she shared her belief about the importance of mathematics, 'You know, mathematics is applied across many subjects and many professions as well' (Maya, Bangladeshi, Female, Accounting and Finance, in-depth interview). Elsa thought that mathematics was important in all aspects, and said, '… maths is the backbone of everything in the world that you do as a career …' (Elsa, Ghanaian, Female, Biomedical Sciences, in-depth interview). The belief expressed by the participants about studying mathematics was widely expressed by the respondents of the survey where 76% of the respondents agreed that *studying mathematics would make them more employable and help them in their careers* (V9). A further breakdown shows that 70% of the males and 81% of the females; 77% of the younger students and 75% of the mature students; and 72% of the Whites, 86% of the Asians, 73% of the Blacks, 80% of the Mixed and 82% of the Chinese and Others agreed with V9. The estimated odds ratio from the Logistic Regression (Table A4.30, p.273) provides the following additional information. The estimated odds of female students among the two gender groups agreeing with V9 were more than four times (OR = 4.26; with a 95% confidence interval of (1.1, 16.1)) when compared with the male students. The fact that this confidence interval was so wide suggests that the estimate of change in odds is not very precise and the actual difference in odds of agreement for the females compared with male respondents could be as low as 1.1 or as high as 16.1. The wide confidence interval could have been the result of a sampling error (not having large number of participants). Between the two age groups the estimated odds of younger students agreeing with V9 when compared with the mature students is 1.57 with a 95% confidence interval of (0.5, 5.4). Using the fitted Logistic Regression model (Table A4.30, p.273) the conditional probabilities P(Agreeing to V9/ Female and young) = 0.975 and P(Agreeing to V9/ Male and mature) = 0.852 are different. Putting these together, both the younger and the female students across all of the ethnic groups have higher estimated odds than their mature and male counterparts in favour of V9. This could be due to a reflection of the positioning of the learning of mathematics as being important by the schools, the media and the society; a position that was still fresh in the minds of the younger and female students. This particular group of respondents, within discourse of mathematics and from what they were told in their pre-university education, agreed the learning of mathematics to be important for their imagined future employment. Furthermore, the responses to V9 across the ethnic groups and within the two age and gender groups are similar; that is, only a small minority in each of the ethnic groups within the age and gender groups disagreed with V9. Nevertheless, the positions of some of the mature participants of the interviewees, for example, Martha (see Sections 5.2) was in disagreement with V9 and said, 'I don't know what maths is useful for; … in my future, NO! For me, my life and for my job, [it is] NO...' As pointed out in Section 5.2, Martha's views about mathematics had been influenced by positioning herself outside mathematics and viewing it as a language for which she did not have the basic knowledge to help her utilize it. Carole doubted the importance of mathematics in all jobs, by saying:

> Even though whatever you [are] doing as a child, you are not
> sure how we are supposed to use it in your everyday life, I

> did not know the application of it....I never quite understood …..[*ha-ha*, laughter]… why is [it] so important? [*ha-hah*]…
> (Carole, White, Female, Biomedical Sciences, in-depth interview).

Carole went further and asked ‘why is it [maths] so important?’ positioning the learning of mathematics as not useful for her future. Carole’s belief about mathematics not being useful in helping in employment and career as a subject was supported by a small minority, 7%, of the respondents. The views expressed by both Martha and Carole on V9 are consistent with their position described earlier about their learning of mathematics.

The view of the respondents on V10 (14.T*he importance given to mathematics in society is over-stated)* the status given to mathematics is further examined. V10 is one of the variables where a big percentage of respondents opted for the 'undecided' option and only 24% agreed while 34% did not agree (Table 4.3, p.80). The Logistic Regression of V10 on gender and age (Table A4.31, p.274) shows that age is significant (p = 0.039) and the younger students are more than two times (estimated OR= 2.2 with 95% confidence interval of (1.04, 4.7)) more likely to agree with V10 when compared with their counterparts the mature students; while the female students are slightly (estimated OR= 1.4 with 95% confidence interval of (0.7, 2.9)) more likely to agree than the male students. Drawing on the results of the analyses, it could be said that the position taken by the younger students regarding V10 could be explained by their view that mathematics being an important subject was diminishing - they had already joined a course that would turn them into a qualified graduate to do the job they wanted to do. Again, this shows that there was a shift in perception about mathematics among the younger students; and for them it is just another subject and hence they consented with V10; while the mature students believed the opposite. Examining the qualitative analysis given in Chapter Five, it can be seen that among the participants in the in-depth interviews, some of the students (Martha, Marr, Carole and Elsa) believed that the importance given to mathematics was overstated, while for the remaining participants it was the opposite.

6.3.2 Mathematics believed essential for professions and the sciences

In an effort to point out the extent to which she found mathematics important in her course, Maya said:

> ...even if you don't like it [mathematics] you should take it up because it is going to be required... In life, I do not think that you have to know [to learn mathematics] in depth...but you [need to] know how to do it without [a] calculator, for example...
> (Maya, Bangladeshi, Female, Accounting and Finance, in-depth interview).

Maya was speaking from her experience as described in Section 5.2 where she had found herself in need of a pre-requisite mathematical knowledge for the modules she was doing at the time. She further pointed out that, 'The purpose of learning mathematics is... it will help the mind to think and encourage people to think more logically, like how and why it came about... And it also stimulates one's brain'. As pointed out in the literature review this agrees with the views of researchers Kounine, *et al*. (2008) and Bramall and White (2000). As shown in Figure 6.1 (p.146), 69% of the respondents of the survey also agreed with the values of learning mathematics as stimulating thinking, creativity and abstraction. Mario was convinced that mathematics was behind every set of knowledge:

> As a subject, I think it is one of the most important subjects above many of the other sciences. It feels to me like a basis of everything. You can't have any type of science without mathematics as a basis
> (Mario, White, Male, Mathematics, in-depth interview).

In contrast with the mathematics students studied by Solomon (2006) who positioned themselves 'as outside of the mathematics community', Mario was speaking from a position of a would-be mathematician who had shown an interest in the subject from his early childhood. On the importance of mathematics for other courses, Rao (White, Male, Mathematics, in-depth interview) believed '…it's a much-needed subject for all courses' and Fiona, doing Biomedical Sciences, expressed her belief about the usefulness of mathematics with, '…as professionals we have got responsibility towards the public in the future. So we need it [mathematics] as we have to be able to do research to improve practices. So we need it' (Fiona, White, Female, Biomedical Sciences, Group A). Similarly, Liz said, '… it is relevant to my subject. Instead of running away from it and later on be in my professional life in problems, I'd rather deal with it now and learn it rather than look away and pretend I know it - for my own sake as well as it is beneficial to my career on the confidence level' (Liz, White, Female, Biomedical Sciences, Group A).

All of the participants of the focus group B indicated their belief about the usefulness of mathematics in their courses; when asked, 'If you were given the chance, would you have preferred not to do mathematics?' Annabel emphatically responded 'No, because mathematics helps you to analyze data' (Annabel, Female, Finance and Banking); and the other participants nodded their head as a sign of agreement to Annabel's response. Furthermore, what could be gained from studying mathematics was highlighted by one of the participants as the 'right skills; certainly concepts and calculation of returns, accounts, etc. but those have implications in terms of your life skills' (Andrew, Ugandan, Male, Finance and Banking, Group B). The belief that the skills gained from learning mathematics being useful in day to day activities was supported by 71% of the respondents (Figure 6.1, p.146).

It may be said that most of the members of the two focus groups and the in-depth interview participants in the study had a strong belief about the usefulness of mathematics in their courses and imagined professions. The implication was that success in mathematics would contribute to a general success in studies undertaken related to their imagined futures within particular professions.

6.4 Factor 5: The perceptions of the Learners' and others about mathematics

I investigated the views of the participants by posing the question 'what is your perception of mathematics and how do people around you perceive mathematics'. The emerging themes from the interviews were: mathematics being difficult, hard and boring; and mathematics being hierarchical. The Principal Component Analysis performed on the quantitative data (see Appendix 4, p.222) provided a set of questions (variables) that could be conceptualized to represent the general perceptions of the learners (Component 5) and others (Component 6) regarding mathematics. The two Components, 5 and 6, are put together to be construct of Perception. The GLM analysis on the Scores of Component 5 obtained from the PCA indicates weak significant regression coefficients of the Score on age and ethnicity only (Table A4.12, p.254) and a similar GLM analysis on the Scores of Component 6 shows weak significant regression coefficients of the Score on gender ($p = 0.069$) and significant on Area of Study ($p = 0.026$) (Table 4.5, p.84). The variables presumed to make up Perception are:

1. *Mathematics is a difficult subject* ***(V11)***
7. *My current perception of mathematics has probably been shaped by what others say about mathematics*
14. *The importance given to mathematics in society is overstated*

5. *People close to me, including my parents, think (or thought) mathematics to be a difficult subject*
6. *When I was younger my teachers said mathematics is a difficult subject.*

Table 4.3 (p.80) shows that high percentage, 15% - 30%, of the respondents were undecided about the statements regarding the perception about mathematics. Nevertheless, it could be said that there was a clear indication from the analysis that the majority of the respondents were likely not to agree with all the five statements/variables. Research have suggested that mathematics is socially constructed, for example as being hard and difficult (Zevenbergen, 1994; Mendick, 2006); while Dossey (1992) and Fuson, *et al*. (2005) describe how differently learners could construct mathematics. These diverse constructions of mathematics interact with the gender, ethnicity, etc. of the learners, which has been studied and presented in Chapter Seven. However, the views expressed by the participants of the in-depth and focus groups interviews are discussed further.

6.4.1 Mathematics perceived as difficult, hard and boring

The variable involved in this category is V11 (1. *Mathematics is a difficult subject*). A detailed examination of the distribution of the responses to V11 shows that 37%, 61% and 46% of the Business, Biomedical Sciences and Mathematics students, respectively, believed that mathematics is a difficult subject. I suggest that the perception that each of the above group has about mathematics being difficult is dependent on the difficulty they faced in using mathematics (this is particularly true of the Biomedical Science students) or the difficulty in understanding the concept (this is what the Mathematics students perceive mathematics to be). It is also observed that almost half (46%) of all the respondents perceived mathematics not as a difficult subject (Table 4.3, p.80). From the Logistic Regression of V11 (Table 4.7, p.88) it has been shown that the regression coefficients for gender are marginally significant ($p = 0.071$) and that of Area of Study (Course) is significant ($p = 0.039$). Moreover the estimated odds of male students agreeing to mathematics being a difficult subject is 1.8 times (with a 95% confidence interval of (1, 3.2)) more likely than the female students. A similar analysis as shown in Table A4.24 (p. 269) shows that the younger students are 1.5 times (with a 95% confidence interval of (0.8, 2.7)) more likely than the mature students to agree that mathematics is a difficult subject. The results of the interviews on the same issue are given below.

Some learners of mathematics tend to view mathematics as a difficult subject because they find it hard to get the correct solution (usually one given by the teacher) for a given mathematical problem. In addition, the discourse of learning of mathematics requires the belief and positioning self in the learning of mathematics (Section 2.4) and this may be achieved by repeated practice/doing of mathematics which some students find boring and too repetitive. Simon responding to the perception question, described mathematics:

> …as a nuisance, complicated, because me [I] and mathematics depart; we're no longer friends….. where it becomes nuisance.….
> It brings frustration then I would rather avoid frustration
> (Simon, Nigerian, Male, Finance and Banking, in-depth interview).

Simon perceived mathematics as a nuisance that brought frustration, and this perception impacted on his emotion (Evans, 2000), which he expressed metaphorically as breaking a friendship. Simon did not want to have anything to do with mathematics. As pointed out earlier learners of mathematics need to spend ample time doing mathematics to succeed and achieve results (Smith, 2002). By perceiving mathematics as a nuisance, Simon may have been drawing on the natural ability discourse and relying on his innate ability only. Simon was completely influenced by the negative perception of others, that mathematics was difficult and hard (Section 5.2) and hence he found that the subject to be in line with the discourse of the nature of mathematics (rigid, one correct answer, etc.). Carole's perception of mathematics was similar to Simon's:

> I believe it is difficult subject... I think it is a difficult subject for lots of people. It is very specific; answers are always a correct answer.

> You know there is no room for debate or discussion about. I think it is quite difficult (Carole, White, Female, Biomedical Sciences, in-depth interview).

And her perception of mathematics as a difficult subject had its basis not on the views of others but on the discourse about mathematics that by its nature of being very specific, answers being always correct, with no room for debate (Schoenfeld, 1992). This is the perception that Carole had from her earlier school lessons (Section 5.2). Elsa agreed with Simon and Carole, by saying that she thought mathematics to be a difficult subject because she did not 'fully understand the complication in maths …and need to have a brain that is able to understand the logical aspects of maths' (Elsa, Ghanaian, Female, Biomedical Sciences, in-depth interview). Ed, a mathematics student, thought otherwise:

> …maths is thought to be one of the most difficult subjects and it is fundamentally not an easy subject; the mass media makes it even more difficult, but with the right environment anybody can do maths (Ed, Nigerian, Male, Mathematical Sciences, in-depth interview).

Here, the right environment implied the pedagogy and the support variables (Sections 5.2 and 6.2). Ed suggested that the media to be responsible for both exaggerating and making mathematics appear difficult and thus beyond the reach of many people. Another mathematics student said, 'Probably it is an easy subject' (Rao, White, Male, Mathematics, in-depth interview) while Mario, also a maths student, perceived mathematics to be difficult because it was an 'intimidating subject, full of numbers, full of equations and when people look at it they back away' (Mario, White, Male, Mathematics, in-depth interview). Harriet explained how the fear of mathematics being a 'difficult' subject could have originated:

> … But I do believe that it got to be passed down from generation in the sense that if my mom and dad were never supportive and said to me 'girl, we told you about it; mathematics, you can just get through …; it is English you need to be good at; …I do believe that what makes you good at a subject is what you are told (Harriet, White, Female, Mathematics, Group A).

Harriet's view is supported by research, and in the UK it is socially acceptable if you find mathematics difficult (Boaler, 2009). This is because traditional mathematics is seen by many people to be full of abstraction which has no apparent application in real-life situation. Marr's perception of mathematics was similar to some of the participants mentioned above:

> …mathematics is boring and clinical…when I was learning it,
> it was a dry subject; it wasn't interesting… You know, one and one
> are two; it is not very easy sometimes…And after a certain degree
> it gets quite difficult to understand; not knowing how to do it…
> (Marr, White, Male, Australian, Biomedical Sciences, in-depth interview).

Marr's perception of mathematics as clinical, boring and dry might have originated from an associated feeling that he did not know how to do it, and even if he attempted to do it he was unable to get the right answer. The perception about mathematics presented above is consistent with the perception of secondary school students who find school mathematics boring and difficult to understand because they do not see any application of it in the real world (Schoenfeld, 1992; Boaler, 2009). This might also be the case with Marr where the mathematics taught to him seemed to have no apparent application in his area of studies and he could not relate to it. Maya, in agreement with the non-specialist participants mentioned above, also perceived mathematics to be rigid and she said:

> …there is no flexibility...you understand it or you don't. Because
> in maths you have the right answer but with other subjects, for
> example English and similar subjects, there is no, as such, the
> right answer... maths is all technical. In one word I say it is difficult.
> It needs a lot of focus, practice, to understand
> (Maya, Bangladeshi, Female, Accounting and Finance, in-depth interview).

In line with the nature of mathematics as lacking flexibility and being technical and its learning requiring practices and focus, Maya found mathematics to be difficult when compared with other subjects.

Putting together the results of the quantitative and the qualitative analyses, it can be seen that the views of the interviewees from the Business and Biomedical students (non-specialists) were identical, that they believed mathematics is a difficult subject. On the other hand, the Mathematics students appeared to re-iterate the views of the non-specialists but they were happy to studying it. The views of the specialists were summarized by Mario, who said '…it [mathematics] got a bit more difficult but [I] still got my head round it'. Similarly, the perceptions of the participants of the two focus groups are also in line with the course they were studying, where the majority of the Biomedical Sciences students believed that mathematics was a difficult subject, while some of the Business, and most of the Mathematics, students doing mathematics believed otherwise.

The positions taken show that the male students were keeping the socially-constructed position of mathematics as a difficult subject; while the female students were challenging it by agreeing with V9 (10. *studying mathematics will make me more employable and help in my career)* and see with the discourse that relate mathematics to high wage earning potential, the advantage of studying it under any external or social pressure.

6.4.2 Mathematics perceived as being hierarchical

Based on discourse in mathematics learning where understanding of mathematics through classroom activities is fostered, learners could benefit if they have the basic knowledge required before new mathematical topics are introduced. This is because discourse of a hierarchy of knowledge inscribes 'mathematics is a hierarchical subject that continually builds upon what has gone before' (Croft, 2002 :144) and most of the topics in mathematics are interrelated; for instance, advanced topic like solving a quadratic equation requires a prior knowledge of solving simple equations. The participants perceived the importance of a prior knowledge in the learning of mathematics. Simon, speaking about his perception of the learning of mathematics said:

> …you learn here [something and] you are going to take it all to the next level and [the] next level. At the start there is a certain formula that we have to understand and that's going to help us more in the lecture. If I don't understand that then I am dead to the rest of the lecture and my mind is somewhere else
> (Simon, Nigerian, Male, Finance and Banking, in-depth interview).

Simon underlined the importance of hierarchical learning by saying a failure of understanding a prerequisite knowledge would lead to his mind wandering and becoming idle and thus making him remain behind in the lecture. Donald's view agreed with Simon's, '...it is very difficult to move up the levels. Once you haven't got the basics then, it is very, very difficult to continue and so that was my main issue with it. I had this gap and I had never resolved that' (Donald, White, Male, Biomedical Sciences, Group A). Donald's experience of not having the basics had been an issue and he was never able to resolve it when he was at school; it left a gap in his knowledge which made it difficult for him to move up the levels in his learning of mathematics. Gamal had a similar view and argued that topics in mathematics were sequential, and that the way one learns mathematics is different from other subjects. He explained by saying, 'It is like a chain and you basically have to start from the scratch… But nowadays people are not willing to do this [start from the scratch] and this is how maths is labeled by the society as difficult' (Gamal, Egyptian, Male, Mathematics, Group A). The views of the participants suggest that any gap left in the previous years of learning of mathematics accumulates to cause difficulty in the present learning.

6.5 Summary

The analysis in this chapter has provided further answers to the research question. Based on their past experiences and within discourses of learning mathematics, almost half (48%)

of the respondents and some of the participants of the interviews agreed to the importance of support made available from the social capital (family or friends) when learning mathematics. Some of the participants pointed out that the socially constructed value of mathematics as an important subject to higher education by different cultures affect the learning of mathematics. Some of the participants also pointed out that cultural background of the learner could play a significant role in positioning mathematics as an important subject to study. Some of the specialist learners, based on their experiences spoke of the support made available from family members acting as a motivational factor to learn mathematics and be good at it; while for some of the non-specialist participants it produced a negative image of mathematics.

The learners have also pointed out that their beliefs about the values of mathematics significantly affected their learning. The perception by the participants of the importance of the skills gained from learning mathematics in their courses, jobs and the sciences have been found to enhance the learning of mathematics. However, some of the non-specialist participants (Carole and Martha) did not believe that mathematics was of any use to them. The non-specialist participants had experienced how discourses about the nature of mathematics and the social construction of mathematics as a difficult, hard and boring subject had to some extent affected their learning. Both the specialist and non-specialist participants perceived the learning of mathematics to be hierarchical.

CHAPTER SEVEN

Third Set of Factors: Ethnicity and Gender of the learner

7.1 Introduction

The participants of the interviews were asked to discuss two issues around mathematics and the ethnicity and gender of the learner. The interviews generated two main themes, the impact of ethnicity and gender when learning mathematics. The Components from the PCA that matched with ethnicity and gender were Components 7 and 8 respectively; and the variables that load on these components are given in Table 7.1. The table shows that 20% - 30% of the respondents did not make their minds about the four statements on ethnicity and gender of the questionnaire. One of the reasons for this high figure of opting to 'undecided' could be that the respondents found the issues related to ethnicity and gender too sensitive and wanted to remain neutral. Nevertheless there is an indication that a large percentage (48 – 73) of the respondents was in disagreement with three of the four statements in the table; while there is a clear indication (46%) that the respondents agreed that the learner's aptitudes to be able to do mathematics is one of the factors that affect the learning of mathematics.

Table 7.1: Responses (in %) of the respondents related to ethnicity and gender

Perceptions regarding ethnicity or importance of gender in mathematics learning	Com-ponent	Agree	Disagree	Un-decided
4.It is likely that some ethnic groups are better at mathematics than others	7	32	48	20
3.One needs particular mental aptitudes to be able to do mathematics	7	46	24	30
32.The learner's gender	8	7	73	20
2.Mathematics is a subject in which male students are more likely to be successful	8	17	55	28

With this background analysis, I investigated the data obtained from the in-depth and focus groups interviews about the views the participants had regarding the role played by the ethnicity and gender of the learner doing mathematics.

7.2 Factor 6: Ethnicity of the learner and mathematics

The participants of the interviews were asked to discuss the view that some ethnic groups are better at mathematics than others. The discussions were found to be based on the extent of the participants own observations while learning mathematics, as described hence. Simon thought that the question must be seen in conjunction with the educational system and the learner's cultural background. He thought Africans were very smart in mathematics at all levels, and he recollected:

> I think from young age they [my parents] were ok [with maths]; my family is from Africa they told me that they learnt because they had to learn it [mathematics] not as choice but no option…
> (Simon, Male, Nigerian, Finance and Banking, in-depth interview).

Another student, Martha, based on her observation of performing mathematical tasks by her colleagues, was of the opinion that '…I think like Japanese people or Indian people might be better because of the culture of just doing it [mathematics] or applying it in task-focused circumstances' (Martha, White, Female, Biomedical Sciences, in-depth interview). Faith gave her carefully guarded view as follows: 'I don't like to make such a comment, but Chinese, Indian and Bangladeshi is [are] good [better] in maths than other Western countries' (Faith, Bangladeshi, Female, Finance and Banking, in-depth interview). Maya also thought some ethnic groups were better in mathematics and gave her justification as follows:

> I think that the Chinese and Japanese are really, really good in mathematics. It is probably they have got it in their genes and have a natural ability towards mathematics. What I am saying is that they must have it within them, in their genes or they might have inherited it from their parents

(Maya, Bangladeshi, Female, Accounting and Finance, in-depth interviews).

It can be seen in Table 7.1 (p.160) that a minority, 32%, of the respondents agreed that some ethnic groups are likely to be better in mathematics than others. In line with discourses of individuality and natural ability, the participants mentioned above believed that it is likely that some ethnic groups are better at mathematics than others. Literature also confirms that differences in achievement (Demack, *et al.*, 2000) and ability in mathematics (Archer and Francis, 2007; Kingdon and Cassen, 2010) between ethnic groups of school age students were observed. It is likely that the students from the ethnic groups identified in Archer and Francis who showed to have ability in mathematics at school level may also show the same ability later in their life. However examining the responses from the survey shows that 72%, 56%, 57% and 50% of the Whites, Asians, Blacks and Others respectively disagreed with the statement that some ethnic groups are likely to be better in mathematics than others.

On the other hand, unlike the non-specialists, a mathematics student Ed (Nigerian, Male, Mathematics, in-depth interview) did not believe that some ethnic groups are better in mathematics than others; similarly Mario viewed mathematics as a universal language and had the view that performances in mathematics is not dependent on the ethnicity of the learner and said, 'It [mathematics] is a subject that anybody with a passion can do it… for people of any race any culture (Mario, White, Male, Mathematics, in-depth interview). This view was supported by 48% of the respondents of the survey data (see Table 7.1, p.160).

The same question was also discussed by the focus group participants. All of the participants from group A did not think that performance in mathematics was dependent on the ethnicity of the learner in any way, while some of the participants from group B thought there was a continental divide as argued by Gore and Kampello, both Male and Nigerians doing the same course. Gore thought that there were differences of perceptions that depended on one's continent of origin:

> You can sort of link ethnicity to it [mathematics] in a way that certain ethnic groups put much emphasis on education. … If you compare that with Europe, the effort you put in…Asians, whatever it is, they are the best; Europeans deal with soft skills that is what I have noticed. Asians [are] more like analytical because they do manufacturing, right. So there is continental variation.

The views on the issue of ethnicity and mathematics as shown above were diverse and dependent on the experiences of the participants and their encounter with colleagues from different ethnic groups in their courses. However discourses on cultural values, norms and principles practised in different ethnic groups have impact on the learning of mathematics (see Section 5.2). The GLM analysis on the Scores of Component 7 (Table A4.14, p.260) shows that there is highly significant difference (p= 0.000) between the overall male and female Scores where the Scores for the female participants are much smaller than the males' (see Error-Bar plot, p.260). This could be interpreted as a lack of agreement by the females to the view that ethnicity of the learner matters when learning mathematics.

7.3 Factor 7: Gender of the learner and mathematics

The participants of the interviews were asked for their views on the issues of gender of the learner and mathematics. The interviews generated two sub-themes that concern the masculinity of mathematics and the performances of the two genders. The two themes are discussed in detail below.

7.3.1 Masculinity of mathematics

The two variables that load on Component 8 obtained from the PCA, which is conceptualized to relate to gender (Table 4.3, p.80) are:

- *32 The learner's gender affects the successful learning of mathematics* (V12)
- *2 Mathematics is a subject in which male students are more likely to be successful* (V13).

The GLM analysis on the Scores of Component 8 (Table A4.15, p.262) shows that there is significant difference (p= 0.033) between the overall male and female Scores where the Scores for the female participants are smaller than the males' (see Error-Bar plot, p.262). This could be interpreted as lack of agreement to the view that gender of the learner matters when learning mathematics by the females when compared with the males'. Further examination of the survey data as presented in Table 7.1 (p.160), shows that the majority of respondents clearly disagreed (73%) with V12. The Logistic analysis given in Table A4.27 (p.271) shows that the male respondents were 1.5 times (with 95% confidence interval (0.5, 4.3)) more likely to agree with V12 when compared with the female respondents; and the mature respondents were slightly (estimated OR = 1.4 with 95% confidence interval of (0.4, 4.2)) more likely to agree with V12 than the younger respondents. In addition the majority of the respondents (55%) did not agree with V13. Further investigation using Logistic Regression (Table A4.26, p.271) shows that the mature respondents were also more than three times more likely (estimated OR = 3.2 with 95% confidence interval of (1.2, 8.6)) to agree with V13 than the younger students. Putting the pattern of the responses for V12 and V13 together indicates that the male respondents held the common view that mathematics is a male domain than did the female respondents. Mendick (2006) also confirms that male students would uphold the stereotyped belief of mathematics being a male subject. Frost, *et al*. (1994) from a meta-analysis of studies on gender differences and mathematics performances confirmed that female students did not view mathematics as a male domain when compared with male students. I examined the data obtained from the interviews.

Simon (Nigerian, Male, Finance and Banking, in-depth interview) said, ‘It never crossed my mind that girls are not good in mathematics’; whereas Elsa based on her observations said, ‘…all the teachers I have and the teachers that teach my children are all male. So I just think generally men are good at maths…’ (Ghanaian, Female, Biomedical Sciences, in-depth interview); Martha (White, Female, Biomedical Sciences, in-depth interview) thought ‘mathematics is a male subject’; Ed thought that tradition had a role in making mathematics look a male subject by saying, ‘…traditionally women are not allowed to take subjects that involve a lot of thinking… so we always thought of maths as a masculine subject’ (Nigerian, Male, Mathematics, in-depth interview); Maya and Faith both Female, Bangladeshi and doing Accounting and Finance and Finance and Banking respectively, and Mario, himself studying mathematics, did not think mathematics to be gendered. Mario philosophically viewed mathematics as:

> …the only true language in existence and that true language is for both boys and girls… throughout history, the development of mathematics has come from various different cultures and from both men and women; you can’t just say that it is just men that can do or just women that can do it. It is a subject that anybody with a passion can do it (Mario, White, Male, Mathematics, in-depth interview).

The majority of the in-depth and focus groups participants had the view that rejected the stereotyped view of a gendered mathematics; a similar view was supported by the respondents of the questionnaire where only 7% believed that mathematics is gendered (see Table 7.1, p.160).

The participants of the focus groups were asked to discuss the question ‘Is mathematics gendered?’ and the topic generated a lively discussion. To start with, two of the participants of the focus group A reacted negatively to the question. Fiona said, ‘I think it is against my belief and a stereotype of mathematicians and I could not answer that question. I do not think it is a good question’ (Fiona, White, Female, Biomedical Sciences, Group A). Ellen, who was doing the same course as Fiona, followed on directly with, 'Like Fiona I think it is a stereotyped question and a myth' (Ellen, White, Female, Biomedical Sciences, Group A). I sensed that there was a misunderstanding, possibly caused by my position (a mathematician), gender (male) and ethnicity (black) asking a question which Fiona and Ellen inferred as challenging their belief regarding the two genders. So, as pointed out in Section 3.5, this was an unexpected ethical issue and it was addressed by me explaining that the focus of the question was to find the views of the participants and that it was not to be taken as an established factual statement, that one gender is positioned to be better than the other. Both Fiona and Ellen accepted my explanation and the discussion continued. Within the progressive discourse of mathematics the female participants, Fiona and Ellen were of the view that the belief mathematics is a male subject is a myth and both male and female can do and understand mathematics (view similar to the one reported by Mendick, *et al.*, 2008) in their study of mathematics in popular culture and Liz, answering the question said:

> No, nothing is just for men or just for women. Historically, it is a male-dominated subject. And for me personally, it was the media or films regarding this subject… because of the society…but at the base of it I do not think that men are particularly better in maths than women or women are better in maths than men; it does not exist. It is because of society and because of this trend we have that more men are going into maths than women (Liz, White, Female, Biomedical Sciences, Group A).

Harriet added:

> … If you look into it, Pythagoras had his colleagues, it wasn't only him; he had like followers; there were people around him who can help him to discover things but it never gets mentioned. But there will have been, I believe, women involved in that. However, because society was male-dominated and that is how we remember it (Harriet, White, Female, Mathematics, Group A).

Both Liz and Harriet justified their position of not agreeing with V13 in line with historical discourse about mathematics. In addition, their view of mathematics not being gendered is in line with the widely held view of the respondents of the questionnaire. As pointed out in Chapter Two (Section 2.6) similar beliefs were reported by the school children studied by Francis (2000b).

7.3.2 Gender and mathematics

Harriet explained how social construction of the genders could affect learners by saying '…if any one speaks about PE, you think of boys doing really well because immediately in your head you get a perception of footballers, obviously there is no massive market for girl football players and things like that have effect on learners'. Harriet's view agrees with the findings of Mendick (2006). Mendick investigating students doing Further Mathematics, found out that although the female students were as good as the male students the female students did not accept that they were good at it because mathematics is constructed to be boys' subject and they wanted to remain 'invisible' (Rodd and Bartholomew, 2006). However, as shown below, four male members from the two focus groups citing empirical examples argued that the girls were marginally doing better than the boys at school age level, a view supported by research as noted in the literature (see, for example, OECD, 2006; DfE, 2012).

Gamal pointed out that in his experience the girls achieved better than the boys in mathematics in his class. He said, '… I mean on equal grounds, it is the girls who are doing much better in maths than us, the boys. Only when we go to university, the girls, they want to be doctors, and they do not want to be mathematicians (Gamal, Egyptian, Male, Mathematics, Group A). Vladimir also cited his experience from school, where the girls performed better than boys, '...in my school where I studied primary and secondary education, the best marks in the school for maths were scored by female students' (Vladimir, Vietnamese, Male, Finance and Banking, Group B).

Donald believed the possible reason for the girls to be better in mathematics lies in the dedication they have:

> I think, from what I know, girls are slightly better in maths at school age because they do slightly better than boys in lots of subjects, only be by a small percentage, just because, may be they are more dedicated at certain ages than boys
> (Donald, White, Male, Biomedical Sciences, Group A).

Andrew, in line with discourse of individuality, effectively said it all depended on the ability and dedication:

> It all depends on one's ability, and it is just ability. Whether someone is good at it or not, you can't break it down in terms of gender. It is all about your hard work and how good you are with maths.
> (Andrew, Ugandan, Male, Finance and Banking, Group B)

During the focus group interviews, the participants at both campuses were asked to discuss the statement that mathematics is a subject in which male students are more likely to be successful. A participant from group B shared his view on the issue as follows:

> …. you can't say one gender is better than the other… So I don't think there is a gender issue, it just is all ability.
> (Andrew, Ugandan, Male, Finance and Banking, Group B).

However, in opposition to Andrew's views, Annabel referring to her teacher's views: 'She believes that male students are better in geometry than female students because they have a better visualization' (Annabel, White, Female, Finance and Banking, Group B). A participant from group B, quoting empirical evidence from his school, disagreed with Annabel, believing that female students are better in mathematics than their counterparts, as described below:

> I do not think that males are better than females in maths. This is because, in my school where I studied my primary and secondary education, the best marks in the school for maths were scored by female students. So I will disagree with that [view].
> (Vladimir, Vietnamese, Male, Finance and Banking, Group B)

Responding to the views expressed by Annabel and Vladimir, Gore attempted to explain why he disagreed with their views and reiterated his view by referring to a popular Channel 4 TV programme, ‘Countdown’, hosted by Carol Vorderman:

> I believe [a] male’s perceptions and [a] female’s perception are different. …You could show Carol 10 numbers… no matter how you look at the 10 numbers, it is just impossible to beat Carol - no matter how long you sit and think. But she looks at the numbers, sort of, in a different way. It is your mind; it is the way you look at the numbers in your mind.
> (Gore, Nigerian, Male, Finance and Banking, Group B)

As far as he was concerned, mathematics was not a male-only or female-only subject. Many people in the UK think of Carol Vorderman as a positive role model of female mathematicians (Mendick, 2006:144); however the media and other social forces have positioned her to be so. Nevertheless a recent report (LMS, 2013) shows that the proportion of female graduates (First Degree) has risen from 40% in 2004/05 to 44% in 2010/11. This is an indication that the construction of mathematics as ‘masculine’ and the various discourses related to mathematics being a male subject is being rejected as some of the participants expressed in the interviews.

7.4 Summary

This chapter explored the views of the participants on the effect of some of the learners’ identity on the learning of mathematics. The statement that ‘some ethnic groups being better at mathematics than others’ was rejected by 48% of the respondents of the questionnaire. Further examination of the quantitative data showed that the majority (50% - 72%) of each ethnic group did not believe that some ethnic groups are better in mathematics than others. A substantial minority (40%) of the one-to-one interview participants, by referring to their classmates from different ethnic groups, who they thought were good at mathematics, believed otherwise.

The quantitative analysis shows that the male respondents were likely to believe that males were more likely to be successful at mathematics than the female students. However, the majority of the participants of the interviews believed that mathematics is not gendered, but the society, the mass media, tradition and some sections of the academia make it look gendered. Furthermore, in line with the discourse of individuality, some of the participants believed that hard work at it and the individual's ability in mathematics make a person succeed in the subject. Drawing on the experiences they have had in pre-university education and discourses about mathematics the majority of the participants believed that learners' gender or ethnicity were not important factors to affect the successful learning of mathematics.

CHAPTER EIGHT

Conclusion, Evaluation and Implications of the Findings

8.1 Introduction

This final chapter reviews the findings of the study; reflects on the research instruments employed for collecting the data; and evaluates the appropriateness of the research methods used to put together the results from the qualitative and quantitative analyses. It also considers how the findings might lead to procedures that could enhance learning for the group of students covered in this study and help them better understand mathematics. Further implications of the investigation and potential future research directions are also considered.

8.2 Summary and conclusion

Through the case study I explored the challenges faced by particular students taking mathematics as an ancillary, but compulsory, subject in order to complete their degree courses. I consider the extent to which my findings answer the main research question 'Why do some mature non-specialist undergraduate first year students taking mathematics as an ancillary subject find mathematics challenging and fail to pass it?' In addition, my findings to the questions posed in Section 1.3 regarding the matching of the learning styles of the mature students with the delivery of mathematics at the university are summarized below.

8.2.1 Summary of the findings

The main findings from the case study considered in my research suggested the following factors were perceived by the students as affecting their learning of mathematics.

- Some of the mature non-specialist Biomedical students indicated feelings of lacking confidence, of not belonging and of helplessness when learning mathematics alongside specialist mathematics students (Section 5.2.2), which in turn affected their learning of mathematics.
- Mature students may have to address challenges arising from their social responsibilities, and their economic and financial positions (Sections 5.2 & 5.3). The participants in the case study perceived that the multiple roles they have been made to play due to these challenges constrained their learning as a whole and compromised their engagement with mathematics.
- Some of the mature non-specialist students thought that not understanding the usefulness of mathematics created a loss of interest and stimulus in learning it (Section 5.3).
- The structure of the courses requires students to study mathematics, yet some of them do not see any apparent application of it in their chosen area of study leading to their lack of identification with the subject. This finding appears to support arguments made by Shaw (1995) that students find it difficult to construct their identities around a subject not related to the careers they are pursuing.
- The amount of time allocated to the tutorial/workshop sessions and lectures did not allow some students (specifically mature non-specialist students who joined the university through widening participation schemes) to construct knowledge and adapt to the lectures (Section 5.2). The students believed that this situation made them to struggle when learning mathematics.
- There were indications from the interviews that the perceptions of mathematics by some of the mature non-specialist students have impacted negatively on their

learning of mathematics (Chapters Five – Seven); however their perceptions also interacted with their age, gender and ethnicity.

- The mature non-specialist students with diverse beliefs about mathematics; attitudes towards mathematics; confidence in mathematics; perceived values of mathematics; and the experiences they have had when learning mathematics did not find the pedagogy used in lectures helpful in accommodating the diversity of the students (Sections 5.2 & 5.3).
- The majority of the students did not think that either the ethnicity or the gender of the learner affected the learning of mathematics (Sections 7.2 & 7.3); but some of them thought that hard work by the learners, coupled with support in various forms made available to them from family and friends, etc. made a significant difference in their performances (Section 6.2.1).

These findings contribute to our knowledge of the learning of mathematics by mature non-specialist students, who have been neglected in both policy formulation and in the academic literature.

8.2.2 Conclusions drawn based on the case study about learning mathematics

I believe that the findings resulted from the case study and summarized above reflect some of the experiences of mature non-specialist students observed in other institutes. I have highlighted below my findings and recommendations that I think could be transferable to other institutes of a similar status.

The majority of the literature reviewed in Chapter Two concerned pupils at secondary school level. The school experiences that learners have prior to joining university have an enormous impact on their learning at a higher level (Schoenfeld, 1992; Crawford, *et al*., 1994; Carlson, 1999; Anthony, 2000; Cox, 2001; Parsons, 2005; Solomon, *et al*., 2011). Many of the mature participants in the in-depth and focus groups interviews, spoke candidly of the effect, positive or negative, of their earlier experiences on their current endeavor in the learning of mathematics. I conclude that recognizing and valuing a student's prior knowledge and experience is an essential aspect of planning courses for mature students.

For many of the respondents (69% - 90%), pedagogy was very important for the successful learning of mathematics. Drawing on their experience the participants indicated that the length of the lecture and tutorial times compromised their learning (Section 5.2). They also believed that relationships with tutors played significant roles in affecting their learning (Section 5.2.3). The preferences of the students in my study were for a short lecture followed by a tutorial / workshop sessions of an unspecified but appropriate duration, where students would be given the opportunity to assimilate and construct knowledge and have open access to get the extra support they needed. The participants believed that such arrangements would allow them to discuss and share problem-solving techniques with colleagues (Section 5.2.2), thus allowing the learners to develop their identity as engagers in mathematics. The students pointed out that the pace was too fast and the teaching methods did not accommodate the learning styles they had developed at a pre-university level of learning. This suggests that it is essential to recognize the methods of the delivery of the mathematics module offered to mature non-specialist students at university level could be incompatible with the learning styles that some students felt they needed.

The length of the lecture, the teaching style and the pace of the lecture appeared more important to both the female and younger respondents than to their counterparts. In addition, this particular group of respondents also agreed that '*regular class attendance* *and seeking help at the early stage'* to be important in the learning of mathematics. Both the male and younger respondents, more than their counterparts, agreed that the aptitude and motivation of the learner to be important for the learning of mathematics (Section 7.3). In addition, as pointed out by Coben (1996: 5) 'teaching should proceed at a pace which suits the learners'', in particular, the mature non-specialist students. As my investigation revealed the learning needs of different groups of mature non-specialist students must be recognised in order to put them on the road to developing their deep learning ability and the construction of mathematical skills.

Furthermore, some of the participants believed that putting together students following different main/principal areas of studies to do the same module had adversely affected their learning. The participants preferred to have their lectures within the context of their particular course and area of study. That is, each subject area should have a class of its own. The students believed that such provision would help them build their confidence and be continuously motivated in their learning activities. Based on this finding, as a module leader for the MA module I put to the Area Group Leader (AGL) this pedagogical case against the teaching of the Biomedical Science and Mathematics students jointly at Campus A. I was given permission to teach the two groups separately on a trial basis. In the autumn semester of the 2010/11 academic year, the MA module was offered to Mathematics students on one day while the Biomedical Science students were taught on two other days. The Business students doing the QM module at Campus B were not included in this arrangement as they were already taught separately from the rest of the two groups. After the introduction of the new grouping, the autumn semester overall pass rate for the MA module increased from 84% in 2009/10 to 92% in 2010/11(Module Log, 2010/11). Based on the evidence of the increment in the pass rate from the trial grouping of the two course groups, it is now a policy for the Mathematics Cluster of the Faculty to provide the module separately for the non-specialist and specialist students. This suggests that if the right resource is made available to run small sized classes of similar subject area it is possible to improve the performances of mature non-specialist students doing mathematics as an ancillary subject.

The dissonance (Ajzen, 1988) between the social obligations of mature students and the requirements of a regular attendance of classes was also considered by the participants to adversely affecting their learning of mathematics. Just over half of the students covered in the study, 53%, had part-time jobs (Section 5.3) to help with present financial needs. The tension resulting from between these two situations – of attending classes on regular basis and of working during term time, put the students in a dilemma and sometimes forced them to compromise their class attendances. Furthermore, dominant discourses about mathematics had created a negative emotion within some of the students, forcing them to position themselves outside of mathematics, to lose their confidence and to disengage from learning mathematics, all of which subsequently affected their achievement in the subject. This indicates the importance that ought to be given to the multi-selves of the mature non-specialist students when designing a course and the recognition of the discourses about mathematics embraced by the learners.

Based on their past experiences of learning mathematics, some of the participants identified the importance of support made available for them when learning mathematics. The source of the support could be the learner's social capital or the institute providing the teaching. The learners' cultural background also played a significant role by providing a basis for positioning mathematics as an important subject to study. Moreover, over 70% of the respondents agreed with '*studying mathematics will make me more employable and* *help in my career*' and was agreed across the three combinations of the constructed identities; gender, age and ethnicity (Section 7.2). The majority (61%) of the Biomedical Sciences students viewed mathematics to be a difficult subject, followed by Mathematics students (46%) and Business students (37%). So, more than half the Mathematics and Business students presumably did not consider it as difficult. Some of the participants perceived mathematics learning as hierarchical (Reid, *et al.*, 1981; Brown, 2003) and the subject as a new language (Sousa, 2008) for which the learners had not been given enough time to learn. In line with deficit discourse where the learner is blamed for the low performance and failure as a lack of ability, some of the participants blamed themselves for lacking the prior knowledge in the hierarchical learning of mathematics as one of the factors affecting their learning. Many of the participants of the interviews and 89% of the respondents of the questionnaire pointed out that '*understanding basic concepts*' was a strategy that they have found to be effective strategy in learning mathematics (Solomon, 2007a; CBI, 2008). If it becomes apparent to the students that the skills they gained from learning mathematics it will enhance their learning; but the social construction of mathematics as a difficult, hard and boring subject has a counter-effect on some students' learning, creating a phobia of mathematics.

As pointed out earlier, when students elect a main subject they construct their identity around that subject. Shaw (1995:113) suggested that 'When we choose subjects [here, mathematics] we are obliged to redefine ourselves and make a public statement about what sort of person we are or hope to be. It is perhaps the first significant choice of identity'. But when students are obliged to do a subject, for example mathematics, irrespective of their choice, they react by asking 'why is mathematics important' (Claire, one-to-one interview); or wish to have their own world 'free of mathematics and nothing to do with it'

(Martha, one-to-one interview) and some even 'run away from mathematics' (Liz, focus Group A). I suggest that one way that could help students develop their knowledge of mathematics and build their confidence is running a bridging course during the summer or for a few weeks at the beginning of the academic year for mature non-specialist students, e.g., Biomedical Science students who join the course through widening participation schemes and prefer not to study mathematics. As (Solomon, *et al*., 2011) indicated the provision of bridging courses helps develop the normative identity of engagement with the subject.

Drawing on their experiences in pre-university education, the majority of the participants believed that the learners' gender or ethnicity did not contribute to the learning of mathematics (Sections 7.2 & 7.3). However discursive practices that have their basis in cultural discourses that discount girls from mathematics, such as differential treatment of appreciation given to male students, biased responses and comments that marginalise girls, etc. and dominant discourses about mathematics that position mathematics as a subject only to a particular group of students could make mathematics to be gendered or ethnically biased. In agreement with a discourse of individuality (ability is related to individuals rather than to gender or other factors), some students believed that hard work, fostered by cultural background and ability that result from 'practice-linked identity' (Nasir, 2002), helped to facilitate the learning of mathematics. My data suggest that a large majority of the students who took part in the study believed that mathematics was not gendered; however a small minority of the mature non-specialists did believe that mathematics was gendered, a view supported by Francis (2000b) and Mendick (2005). The male students in the case study were more than three times as likely to believe that male students are more likely to be successful in mathematics than female students, a view that was opposed and rejected by the majority of female respondents (Section 7.3). In addition, contrary to the belief that mathematics is an important subject (Cockcroft, 1982) the younger students believed that the value given to the learning of mathematics is overstated (Section 6.3). I believe recognition of the prevalent discourses about mathematics and the resulting discursive practises could help lecturers approach the teaching of mathematics in a way that benefits the majority of the different groups of the mature non-specialist students.

In conclusion, I suggest that my research has gone some significant way in answering the research questions by identifying the perceived factors that affect the learning of mature non-specialist students who have to do mathematics as ancillary subject. According to the students who participated in the research, the pedagogy; the learner's attitudes, beliefs and perceptions; and the support available to them were perceived to affect their learning of mathematics. However the impact of each factor, as explained earlier is dependent on the constructs of the identities of the learners. The awareness about the existence of these perceived factors can help lecturers understand how students perceive and learn mathematics; and accordingly adjust their mode of delivery of the subject and the perceptions of the learners' in order to minimize the problems that may arise in the learning processes. The findings of my research show the importance of understanding the wider needs of the complex lives of contemporary students to address the problematic nature of mathematics teaching and learning.

8.3 Evaluation of the research design: a reflection

The evaluation of Mixed Methods Research /Design involves examining the plausibility and trustworthiness of the findings, where plausibility refers to the linkages between data and the findings while trustworthiness refers to how the evidence is produced for it to be credible (Robson, 2011). It then becomes necessary to audit the process followed to achieve the claimed end results. I begin reflecting on the design chosen to be implemented in the enquiry.

As explained in the previous chapters, the main reason for choosing the Mixed Methods Design was to achieve deep understanding of the challenges that some students face doing mathematics as an ancillary subject. The enquiry was guided by the main research question that was given in Section 1.3. Due to a limited experience in running a Mixed Methods Research and the limited time I had to complete the data collection, I framed a single main research question. As I pointed out in Section 3.2 one of the limitations of the Mixed Methods Research is whether or not to use separate questions for the two paradigms (qualitative and quantitative). Upon reflection, the main research question could have ideally been framed to incorporate both the qualitative and quantitative nature of the enquiry. However positioning myself as pragmatic and seeking to explore the perceived factors affecting the learning of mathematics, I had subsidiary sets of questions that allowed the collection of both qualitative and quantitative information (Section 3.4). The design implemented had enabled me to address a wide range of research questions – one of the strengths related to the Mixed Methods Research. The analyses of the collected information comprehensively pointed to the perceived factors affecting the non-specialist students when learning mathematics.

The way the information is gathered, analyzed and interpreted is central to the evaluation of the research. Creswell and Plano Clark (2011:267) state ' ...mixed methods research must be responsive to both qualitative and quantitative evaluation criteria …[however] there is a separate set of expectations for mixed methods study beyond those needed for quantitative and qualitative research'.

Accordingly a purposive sampling technique was implemented to select participants in the one-to-one interviews. The selection included those mature students who I believed, from my observations of them and working with them in classes would provide relevant data on the basis of their own learning experiences of the subject. As I pointed out in Section 3.2 one of the limitations of Mixed Methods Research is the temptation to allow individuals to take part in more than one sampling subgroup. Upon reflection, with a proper planning and the choice of appropriate sampling frames, I was able to avoid using the same individual(s) in more than one sampling subgroup. This safeguard is one of the strengths of the sampling scheme and the procedure used to collect the data. The credibility of the findings is thus assured by the sampling technique implemented. However, upon reflection the sampling technique did not go far enough to include younger students in the one-to-one and focus groups interviews. Data obtained from the younger students on their experiences of learning mathematics at school levels would have given me an additional dimension to consider in light of the data already collected through the interviews from the mature students; thereby making the findings more comprehensive.

The formation of the two focus groups was based on the two campuses of the university. Focus group B was a homogeneous group of non-specialist students while focus group A had both specialists and non-specialists as its members. As indicated in Section 3.4 it is advantageous to have all members of a focus group from a similar background. In hindsight I should have divided focus group A into specialist mature and young; and mature and young non-specialist students thereby having three focus groups in total. This would have given me additional opportunity to independently collect data from the three groups. However due to the unavoidable constraints of shortage of time that arose from additional job responsibilities I was not able to deal with more than the two focus groups within the time frame I was given.

8.4 Implications of the findings for practitioners and policy makers

I now discuss the implications of the results, obtained from the case study undertaken at the post-1992 inner-city university in London, with a particular focus on how they might be used to affect the teaching and learning of mathematics and the design of the curriculum for the mature non-specialist students.

As indicated in Table 1.1 (p.8) the sampled failure rates in the two modules (QM and MA) are not acceptable and as a basis for answering my main research question, 'why do some mature non-specialist undergraduate first year students taking mathematics as an ancillary subject find mathematics challenging and fail to pass it', I found it convenient to look at a case study on students selected from the institution I am working for. My research findings resonate with the research studies carried out, for example, by Croft and Ward (2001), Tariq (2002), Sabin (2002) and Warwick (2008) although the focus of these studies was on different type and demographic of students from the students covered in my study.

My investigation led me to closely examine the admission policy of the institute to its Courses. As I have indicated in Section 1.2.2, the University, within the framework of widening participation, provides fair access to its wide variety of undergraduate courses to candidates from the non-traditional group of applicants who do not meet the 'normal' entry requirements to some of its Courses. For example, the 2008/09 undergraduate prospectus of the University indicates those applicants over the age of 21 and who lack formal qualifications may be offered Preparatory or Access courses like HNC, HND and FD with a long-term possibility of achieving their aspiration for a degree qualification. It would appear that this information is typical over the previous many years. The prospectus makes it clear that the University commits itself to 'best meet the needs' of students who have the 'ability to benefit from higher education' in accordance to the general widening participation policy of the government (DfES, 2003). Underpinning this ethos and a commitment to providing students with quality and standards, in 2011 the University was awarded the highest grade from the Quality Assurance Agency (QAA) review for its academic standards and learning opportunities. It also received funding from Higher Education Funding Council for its widening participation activities. As pointed out in Chapter One it is not a surprise that the majority of the students at this post-1992 university are mature students (HESA 2011b). This group of students is likely to include those who are required to do mathematics against their likings; or who lack confidence in the subject and have disliked it since their school age; and who do not see any relevance of mathematics in their imagined future career. However the widening participation policy does not take into account and make sufficient resource available to treat this particular group of students as a special group. Croft (2002: 151) suggested that a due attention needs to be given to this group of mature students, and that institutes dealing with such students ought to be adequately supported and resourced. A shift of government policy on the access and financing of such students is necessary.

Further, I examined the prospectus of this particular university for the 2012 onwards applicants regarding the continuation of the widening participation policy. In the prospectus, the university clearly welcomes applicants by saying '…join us, regardless of age, background; [w]e will insure that you have the best possible university experience'. As pointed out by Graham (2013:78) a change of government brought a shift of policy towards a 'customer – focused' HE system and higher education institutes must take individuals with highest academic potential suggesting a 'narrow interpretation of the existing widening participation policy'. McCaig (2011:125) also revealed that because of changes in government policy on widening participation, post-1992 universities have started promoting their programmes as attractive to a wider cohort of potential students, or market the image of their institute as prestigious by withdrawing, for example, Access Courses, HNDs, etc. The impact of the marketization of education remained an important factor putting universities under pressure to maximise student numbers. This is the option that this post-1992 university is forced to adopt; in the future only students who are believed to have the ability to succeed (instead of *to benefit*) are recruited. Will this overcome the mathematics problem highlighted in my research?

The location of the two campuses of the university allows its students to get temporary employment often in the service industries, during term times. The Survey data from the study showed that 53% of the respondents were in part-time employment to help with their present financial needs (Table 4.2, p.77). This meant that some students regularly compromised their attendance of classes. My findings suggest the social obligations of some students adversely affect their learning of mathematics and their regular attendance of classes. My research shows that the economic burdens and loans for fees meant that many mature students, who also have social obligations, are forced to compromise on the time they make available for study. In order to take some of the financial burden away and give the learners more time for their studies, some form of mechanism for financial support for mature students needs to be made available.

The findings of this case study as presented in Section 5.2 show that non-specialist students were put together with specialist mathematics students to do a common MA module. There is evidence (for example Croft and Ward, 2001) that putting students from different courses together to do a common module is also practiced in many universities. The reason for grouping non-homogeneous students together could be to reduce the cost of running the courses. The students in this study felt that such grouping negatively affected their learning and suggests grouping students according to their area of study would stimulate their learning of mathematics. Implementing would come with a cost in employing additional lecturers, classrooms, and so on. Grouping small numbers of students by main subject may not be financially viable. The case I presented earlier, separating students into non-specialist and specialist group on the MA module (see above) was accepted by the Faculty, because there were in excess of 200 students taking the module. Teaching and learning mathematics would have great success rates if small-sized classes are allowed and resourced to run because small sized classes would create opportunities to address the needs of individual students thereby improving the teaching and learning of mathematics of non-specialist mature students.

As presented in Chapter One, the student composition of this post-1992 university was highly diverse: almost half of the students are from minority ethnic communities; more than half were mature, and well over 90% were from state schools or colleges; a large minority, over 40% of the students were from the lower socio-economic groups; and the students' non-continuation rate as extracted from the performance indicators from HESA (2011b) shows that nearly 25% of the 2009/10 entrants to this university did not continue to the next year. Croft (2002:151) points that one of the reasons for failure or withdrawal from courses is claimed to be the difficulties students face in learning mathematics. The diversity of mathematical skills within groups of students with the range of background indicated above makes it hard for teaching staff to satisfy all groups. It is not easy for the lecturer to provide a balanced teaching to fit the learning styles of such mix, particularly because of the variety of the learning styles that students encountered before they come to university. For instance the non-specialist participants stressed the importance of having a short lecture followed by an appropriate length of tutorial or seminar sessions, and such action requires either making the syllabus thinner, by omitting some of the unpopular topics, or running the module for a year rather than a term. This option would need to be resourced and the curriculum redesigned.

My research has also shown that the learning styles of mature non-specialist students do not match the pace of the lectures. Lecturers have tight teaching schedules to cover the topics required, and such a pace may not fit the learning styles of many of the mature non-specialist students, especially those students accepted through widening participation programmes for courses requiring mathematics as an ancillary subject. This issue could be addressed by providing bridging sessions or supplementary introductory mathematics classes before the start of the formal teaching. Attending these supplementary classes could be made mandatory and passed for new applicants as an entry requirement. This would build the confidence of the learners (the belief of the individual to do mathematics) and fill-in the basic mathematical knowledge not covered during their pre-university education. However, this would require additional resources and a concerted university-wide programme; and revising Higher Education policy to make these resources available. Teaching which promotes both conceptual and procedural knowledge is needed if students are to apply the skills with confidence and to a specific purpose.

Research shows that many of the students who join universities take courses requiring some mathematics come with limited mathematical experiences (Sutherland and Dewhurst, 1999; Croft and Ward, 2001; Parsons, *et al.*, 2009), and this limitation affects the quality of the learning. Universities across the UK have addressed this limitation through mathematics Support Centres, where students are given help outside class hours when needed (Matthews, *et al*., 2012). In this particular university the Maths Clinic, a mathematics support session, runs for two hours around lunch time daily for the whole week during term times. A senior staff member is responsible for running the Maths Clinic and support in the Clinic is given by qualified visiting lecturers in mathematics/statistics with experience of teaching and tutoring. Students can use the Clinic for as little time as required to address the question they came with, and support is tailored to fit the needs of the individual. My experience of running the Maths Clinic, as indicated in Chapter One, confirms that very few students use the Clinic during term times and a huge number during the weeks in the summer term where the re-sit examinations take place. The challenge has been to attract students who know that they are at risk to use the support available at the Clinic. The issue of student reluctance to use the Clinic needs proper investigation, but the following issues may need to be addressed first.

In this particular university the mathematics support was made available at two of its campuses. As pointed out earlier, students taking courses at Campus B had to make an additional journey to Campus A if they needed any help in the Maths Clinic on those days the QM module was not taught at Campus B. This meant students incurred additional travel expenses. Offering mathematics support session at both campuses throughout the term would have resource implications but such investment would benefit both learning and teaching processes, and improve the success rate.

Other findings of the study showed that mature non-specialist students regarded mathematics as having no relevance to their courses; and as a result, it is given low priority by the students. These students have very low confidence in studying mathematics and thus position themselves as outside mathematics. These perceptions of mathematics and the discourses that position students in relation to mathematics act as barriers to seeking additional support and need to be challenged. Solomon, *et al.* (2010) point out how a Mathematics Support Centre created an environment for female students to discuss and challenge the discourses of mathematics that impacted negatively on their learning. Negative perceptions created by discourses of mathematics on students learning mathematics could be addressed by the staff; and one way could be that all teaching staff in the department where the course is housed and the mathematics teaching staff to collaborate in showing the students the potential uses of mathematical knowledge in their main course. The collaboration of various staff involved in demonstrating to learners how mathematical knowledge is required by providing mathematical examples and exercises of direct relevance to the course. I believe that if students are made aware of the support available, and if staff closely monitors their attendance and performance this will encourage students at risk of failing the module to use the additional support provided by the university at an early stage.

Staff involved in delivering the tutorial / workshop sessions all have possible opportunities to closely assess the progress of each student. If staff advise and follow up students at risk of failing the module, supporting regular attendance at the Maths Clinic and explain the conducive environment for learning provided, such as learning at one's own pace; asking questions that seem basic and be guided to solve it; providing additional exam type questions where the student is encouraged to spend time working on them during their independent study; and to ask simple questions without embarrassment. I believe intensive advertisement of the benefits of attending the Maths Clinic will encourage the students to make effective use of the facility.

8.5 Suggestion for future research

Finally, by conducting this research I have become more aware of the effect of the various academic and social experiences that students bring with them, the roles that the constructed identities of the students could play and how students position themselves when learning mathematics. I am convinced that an empathic staff should accommodate extraneous factors beyond the learners' control and adjust their approach and teaching methodologies that meet the needs of the students.

I understand the results obtained from the case study undertaken at this post-1992 inner-city university in London have implications on the curriculum design and delivery, admission and funding policies practiced. However, there are several areas that prompt additional research:

1. The inclusion of non-specialist younger students in the interview - the interviews included only mature students. With hindsight, and drawing on the results from the analysis, non-specialist younger students should also have been included in the interviews. The results from the quantitative analysis, for example, of the factors affecting younger group of students when learning mathematics does not go any further in supplying the reasons as to how this occurs. Future research of a similar nature conducted here should have equal number (ideally) of non-specialist younger and mature students in both the in-depth and focus groups interviews and assess the consistency of the factors believed to affect the learning of mathematics.

2. The inclusion of the social class of the student as a variable affecting learning - the literature review given in Chapter Two shows that the social class of the parents of the learners plays a significant role in the attainment of the learners and the

interviews in my research confirm this too. A future investigation along a similar line of enquiry would benefit from including the social class of the parents or the mature students (if different from their parents) as a construct of their identities and explore its effect on the learning of mathematics. Nevertheless I acknowledge that categorizing such diverse students in a meaningful social class groups might be hard; however it should be attempted.

3. The mode of teaching mathematics to non-specialist students - as pointed out in the literature review, mathematics is positioned as a utilitarian/ own right subject. Current debate in the UK indicates that mathematics is mainly taught as a utilitarian subject. A future study needs to look at how mathematics as a utilitarian subject should be taught for mature non-specialist students, either as a separate subject by its own or integrated into other subjects; and by whom it should be taught – mathematicians or non-mathematicians but subject related experts.

4. Assessing the effectiveness of the Maths Clinic[34] - students do not make use of the Maths Clinic, a mathematics support/drop in center where help is offered outside the normal class hours. As pointed out in Chapter One although some of the students know that they are struggling in the subject they seemed to be reluctant to make use of the Maths Clinic. Research on determining the barriers of accessing support offered by the Maths Clinic and the level of participation of the students in the Maths Clinic would be useful. Exploring the three stakeholders, those who use it; those who don't use it; and the staff that do the tutoring, could shade some light on the effectiveness of support provided by the university.

[34] Sigma (∑), the network for cross-university mathematics and statistics support, accepted my proposal and agreed to partially finance the research that I plan to begin early in August 2014.

8.6 Closing remarks

I believe that this research is especially significant because it reveals the challenges faced by mature non-specialist undergraduate first year students taking mathematics as ancillary subject as a requirement of their degree courses. It suggests changes need to be made at government and at institution levels to address the challenges. At government level, due attention needs to be given to this group of mature students, and that institutions who deal with such students should be adequately supported and resourced. A review of the financing mechanisms for HE mature students is necessary to avoid inequality and social injustice. At institutional level, in line with the ethos of widening participation, there needs to be curriculum development to accommodate the diverse mathematics backgrounds of mature students and the development of a mode of delivery that takes into account the different learning styles of mature students. These measures would lead to more successful retention and progression rates. A well-developed mathematics support provision could provide opportunities for mature students to engage in mathematics and construct their mathematics-related identity. It would address the discourses and discursive practices that compromise the learning of mathematics by mature students. I hope that this study provides a useful contribution to our understanding of the factors perceived as affecting the learning of mathematics by mature students and practitioner knowledge to better support the learning of mature students.

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Appendices

Appendix 1: Essentials prior to the gathering of data

This appendix contains the ethical statements approved by the university's ethical panel, a copy of the invitation letter given to potential participants**,** a consent statement that the participants were asked to sign and background information sheet that all the participants had to complete.

Ethical statement in support of Ed D thesis application

The nature of the data I intend to collect is biographical in the form of personal stories; that is various past and present stories surrounding the experiences of learners at a post-1992 University while studying mathematics. However, the collection of biographical data from human subjects raises some ethical issues which are addressed below.

To gain informed consent, an invitation letter (see below), outlining what the research involves, will be sent to all respondents. Those who agree to take part will be asked to fill in the short information sheet and sign the consent form indicating they understand what they are consenting to.

I would comply with the requirements of current data protection legislation and this will be accomplished as follows. All data collected from participants will be transcribed and stored anonymously where I will be the only person that knows its identity. However, my supervisors might read it where the data will be anonymised using pseudonyms for use in the thesis.

Confidentiality and anonymity will be safeguarded and no information that discloses the identity of any respondent will be released or published. In order to get feedback from the participants on the accuracy of the content of the data collected I will send them copies of the transcripts. I will also stay in touch with the participants and make myself available to answer questions after the interviews/focus groups have taken place.

A respondent will be informed that, if they wish to, they can withdraw from the study at any time and refuse to answer any particular question. Although not anticipated to happen, if a participant gets upset in the interview I will try to calm them down and direct them to the Student Counselling Services where they can get an expert advice and additional support if necessary.

In any research, the position of the researcher raises ethical issues. My multiple roles as an 'insider', for example, as a lecturer/assessor and Black male researcher could raise ethical issues that need to be addressed. My position as a lecturer of mathematics will give me the advantage of executing the interview from a position of having information and knowledge of the context of the study. This position will enable me to ask more meaningful questions and gauge the non-verbal signals from the participants. However, this could create a misrepresentation of the 'voice' of the participants. It will be my responsibility to conduct personal reflexivity that involves reflecting upon the ways in which my own values and identities (as a lecturer, and Black male researcher) may/ may not have altered the voices of the participants. I have set a procedure to address the ethical issues mentioned above and the procedure will be tested and refined by a pilot study. And as a professional academic it will be my responsibility to honour all the agreements I have made with my students and the University.

An invitation letter to potential participants

Dear Student,

I am writing to you to invite you to participate in research I am conducting into non-specialist first year students' experiences of learning mathematics. The research is for a degree (Ed D) I am undertaking at a post-1992 University and supervised jointly by Dr Uvanney Maylor [Professor Alistair Ross] and Dr Kimberly Allen. This is a preliminary request for participation and I am inviting a number of students to take part in my research and from which I will only select some as part of my purposive sample. I reassure you, as a potential participant that if you are not selected for actual participation the information that you supplied to me in the first instance (on which my selection is based) will be destroyed.

Examination results in GCSE and A-level mathematics have been a concern for various governments in the UK for many years. Various inquiries sponsored by governments identified that 'mathematics is a difficult subject both to teach and to learn'. It is thought that a similar trend is observed at university level too, especially among non-specialist students. However, this needs to be investigated and supported by data. I am, therefore, inviting voluntary first year undergraduate students who will be purposively selected to take part in an interview or focus group which I plan to carry out over the current academic year.

The research will involve in-depth and focus group interviews which will solicit students' experiences of learning mathematics, including learning mathematics at London Metropolitan University. My aim is to develop a greater understanding of the factors that affect mature, non-specialist undergraduate students when learning mathematics. The result of the research will be made available to the academic world through dissertation and publications.If you agree to take part, the interview will take place in the university or at a location that is suitable and convenient for you. The interview will be audio-recorded and it is expected that it will not take more than one hour.

To protect participants' confidentiality and anonymity, I will comply with the requirements of current data protection legislation and this is accomplished as follows. All data collected will be transcribed and stored anonymously where I will be the only person that knows its identity. However, my supervisors might read it and it might be used in a report of the research but anonymised using pseudonyms. Confidentiality and anonymity will be safeguarded and no information that discloses the identity of any respondent will be released or published without the specific consent to the disclosure. If you take part, you can withdraw from the study at any time and refuse to answer any particular question. In addition, if you decide to withdraw at any stage any information collected from you will be removed from the study and destroyed. All respondents who are happy to take part in the research will be asked to fill in a short information sheet and sign the consent form below.

I very much hope that you agree to participate in this research. Questions about the research in general or about the role of the respondent in the study, could be addressed to me either by e-mail (g.zergaw@londonmet.ac.uk) or telephone on 02071334388.

With kind regards,

Getachew Zergaw

Consent Statement

1. I understand that my participation is voluntary and that I can withdraw from the research at any time without any consequences and without giving any reason. If I decide to withdraw at any stage, I understand that any information collected from me will be removed from the study and destroyed.
2. I am aware of what my participation will involve.
3. I understand that the information I give during the research will be held in confidence.
4. All questions that I have about the research have been satisfactorily answered.

I agree to participate.

Participant’s signature: ___________________________________

Researcher’s signature _______________________________

Date: __________

Background Information sheet

The following background information details are being requested because this will help me in analysing the data provided by respondents specifically in relation to deriving a better understanding as to whether there are any associations between students’ experiences of learning mathematics and their gender, ethnicity and age. This is a voluntary request which you are not obliged to comply with. If you have any questions or concerns in completing this form please do not hesitate to contact me either by e-mail (g.zergaw@londonmet.ac.uk) or telephone on 02071334388.

Name: --

Gender: ------------------------------

Age (circle one as appropriate, please): 18-20; 21-25; 26-30; 31-40; 41 or over

Ethnicity: ---------------------------------

Area of Study (circle one please): Science /Mathematics Finance

Registration (circle one please): Full-time Part-time

Nationality for the purpose of fees (circle one please): UK Home Other EU Overseas

Thank you

Appendix 2: Interview schedules (with prompts)

This appendix provides the interview schedules employed in the interviews with outline of the questions.

Introduce the research:

- provide assurances of confidentiality and anonymity in that - what is said in the interview will not be communicated to anyone else;
- the report will be written in such a way that individuals are not identifiable in any way;
- interview will only be recorded if permission is granted by the interviewee;
- no one else except the researcher will have access to the recorded interview.

Introduce interview Topics:

- Perception of mathematics as a subject;
- Educational experience in general;
- Experience of learning mathematics at a post-1992 University.

Interview questions:

On perception....

- What is your view [perception] of mathematics as a subject? Could you please elaborate?
- At your home, how was mathematics seen [perceived]? Among your friends? In your neighbourhood? Did this have effect on you? Could you explain further?

On educational experience....

- Could you share with me the general educational experiences you have had since your primary school?
- What is your general feeling about the experiences you have had? Have your experiences affected your learning? In what way, please elaborate.
- Could you demonstrate the state of your feelings over the years by plotting feelings vs your age on the graph provided.

On experience of learning....

- How did you find your first year modules? Could you give me reasons why?

- How would you describe your experiences while learning a maths module? Could you elaborate on your answer please?
- What are the factors that affected your mathematics learning? Explain in what way?
- Could you plot on the provided graph paper your achievements in mathematics examinations you did over the years?
- Looking back, could you suggest any changes that must be made to the first year mathematics modules in your course? Why the changes?
- If you were to do the mathematics module you did, what ‘things’ would you have changed? Explain.

Appendix 3: Questionnaire

Student's experiences of learning Mathematics: a questionnaire to be completed by first year MA and QM module Students.

This questionnaire is for a research study of student's experiences of learning mathematics. So that I can compare their experiences to those of other students, I am inviting all first year students to complete the questionnaire below. The questionnaire will take approximately 15 minutes to complete and your answers will be very valuable to my study. The information provided will remain confidential.

Thank you for participating in completing this questionnaire.

Getachew Zergaw (contact e-mail address: g.zergaw@londonmet.ac.uk)

I. Perception about Mathematics:

In the following, circle one of the options given as you think appropriate where 1= Strongly Disagree; 2=Disagree; 3= Undecided; 4=Agree; 5=Strongly Agree.

1. Mathematics is a difficult subject. **1 2 3 4 5**

2. Mathematics is a subject in which male students are more likely to be successful.
1 2 3 4 5

3. One needs particular mental aptitudes to be able to do mathematics.
1 2 3 4 5

4. It is likely that some ethnic groups are better at mathematics than others.
1 2 3 4 5

5. People close to me, including my parents, think (or thought) mathematics to be difficult subject. **1 2 3 4 5**

6. When I was younger, my teachers said that mathematics is a difficult subject.
1 2 3 4 5

7. My current perception of mathematics has probably been shaped by what others say about mathematics.
1 2 3 4 5

II. **Value of learning Mathematics:**

In the following, circle one of the options given as you think appropriate where 1=Strongly Disagree; 2=Disagree; 3= Undecided; 4=Agree; 5=Strongly Agree.

8. Learning mathematics is important because I use the skills I learn in my day to day activities. **1 2 3 4 5**

9. Studying mathematics stimulates my thinking, creativity and abstraction. **1 2 3 4 5**

10. Studying mathematics will make me more employable and help in my career. **1 2 3 4 5**

11. Achieving ***C*** or a better grade in GCSE/A-levels mathematics should be a general entry requirement into universities. **1 2 3 4 5**

12. My friends and family will respect me more if I am successful at mathematics. **1 2 3 4 5**

13. People who are good at maths are successful in life. **1 2 3 4 5**

14. The importance given to mathematics in society is over stated. **1 2 3 4 5**

III. **In my experience, I find the following environments help stimulate my mathematical learning**

In the following, circle one of the options given as you think appropriate where 1= Strongly Disagree; 2=Disagree; 3= Undecided; 4=Agree; 5=Strongly Agree.

15. Having extra assistance (such as a tutor) available **1 2 3 4 5**

16. Being in a class of students with similar ability **1 2 3 4 5**

17. A short lecture followed by a tutorial session **1 2 3 4 5**

18. Worked examples with exercises to solve **1 2 3 4 5**

19. A lecture that works at my pace **1 2 3 4 5**

20. The teaching techniques employed **1 2 3 4 5**

21. None of the above apply to my experience **1 2 3 4 5**

IV. In my experience, I have found the following strategies to be effective for learning mathematics

In the following, circle one of the options given as you think appropriate where 1=Strongly Disagree; 2=Disagree; 3= Undecided; 4=Agree; 5=Strongly Agree.

22.	Memorising formulae	**1**	**2**	**3**	**4**	**5**
23.	Working hard at it and solving as many problems as possible	**1**	**2**	**3**	**4**	**5**
24.	Understanding basic concepts	**1**	**2**	**3**	**4**	**5**
25.	Developing an interest in mathematics	**1**	**2**	**3**	**4**	**5**
26.	Relating mathematics skills to the real world	**1**	**2**	**3**	**4**	**5**
27.	Attending classes regularly	**1**	**2**	**3**	**4**	**5**
28.	Seeking assistance at an early stage	**1**	**2**	**3**	**4**	**5**

V. In my opinion, I think the following are important factors that affect the successful learning of Mathematics

In the following, circle one of the options given as you think appropriate where 1=Strongly Disagree; 2=Disagree; 3= Undecided; 4=Agree; 5=Strongly Agree.

29.	The learner's natural ability to do mathematics	**1**	**2**	**3**	**4**	**5**
30.	The learner's attitude & motivation towards mathematics	**1**	**2**	**3**	**4**	**5**
31.	The learner's past experience of mathematics	**1**	**2**	**3**	**4**	**5**
32.	Support and encouragement of learning mathematics from your family	**1**	**2**	**3**	**4**	**5**
33.	The learner's gender	**1**	**2**	**3**	**4**	**5**
34.	The learner's self confidence and belief regarding mathematics	**1**	**2**	**3**	**4**	**5**

VI. About your background: So I can understand your answers better, it would be useful to know a bit more about you. Please circle one of the choices given below that fit you

- My gender is: (1). Male (2). Female
- My age group is: (1). 20 or below, (2). 21 -25, (3). 26 -30, (4). 31 – 40 (5). 41 or over
- My ethnic background is ---

- Area of Study:
  (1). Business (2). Science (excluding Maths) (3). Mathematics
  (4). other (specify, please) ----------------------------------

- Are you a Full–Time or Part-Time Student? (1).Full-Time (2).Part-Time

- Do you have additional responsibilities, like caring for children or other family members? (1). Yes (2). No

- Do you work part-time or full time while studying at University? (1). Yes (2). No

- Your highest qualification in maths is at which level:
  (1).GCSE (2).A-Levels (3).Other (specify, please)………………..

- Your pre-university highest mark you scored in Mathematics:
  (1). ☐ (2.) don't remember it.

Many thanks for your time. Your answers are extremely valuable to my study.

Appendix 4: Quantitative data analysis

A.1 Introduction

My investigation focused on an understanding of the contribution of the respondents' characteristics to the views expressed in the answers to the questionnaire about mathematics learning. A five-point Likert scale where 1 = Strongly Disagree to 5 = Strongly Agree was used to get the responses to the questions by the students covered in my investigation. The characteristics of the learners being considered were their gender, age, ethnicity, Area of Study (Business, Biomedical, Mathematics), Status (full- or part time students), Additional Responsibilities (at home, part-time employment) and Qualifications gained in mathematics at various levels (including GCSE and A-levels). The collated data set could be explored according to the information obtained from the questionnaire. The collected data is summarised in Table 4.2 (p.77) and it was analysed using SPSS as explained below.

A.2 Data reduction procedures

There were 33 statements (variables) in the questionnaire that the respondents were asked to indicate their choice according to whether or not they agree to a given statement. In order to carry out analysis on the data set, the internal statistical consistency and reliability of the 33 items, or variables, used in the questionnaire were assessed using the Cronbach's alpha index. The index assesses 'the degree to which responses are consistent across a set of multiple measures of the same construct' (Warner, 2008:1005). It is generated by using the mean of all the inter-item correlations to assess the degree of agreement among individual test-items measure the same construct or concept and then predict the reliability coefficient: the higher the Cronbach's alpha, usually greater than 0.70, the better the internal reliability (Kline, 1994). SPSS produced an alpha index of 0.806 for the 33 items used in the data (Table A4.1), suggesting that the variables were measuring the same attribute.

Table A4.1: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
.806	.828	33

This value confirms that the responses have fairly internal consistency reliability and so formal quantitative procedure in particular Principal Components Analysis could be used to analyse the data.

There are a number of quantitative methods of analysis that could be used in the analyses of the collated data that had been coded and entered into SPSS. One of the procedures implemented in this analysis is Principal Components Analysis (PCA), a technique used to identify the small number of constructed variables, called components, from the data that are needed to define the whole data set without leaving a large amount of variance unexplained. The analysis was performed in two stages, factor extraction and factor rotation. With factor extraction an attempt was made to select the important components underlying the data. In factor rotation, the goal was to make the pattern of correlations between the extracted components and the variables more interpretable. The orthogonal rotation method was used to achieve this goal.

Principal Components Analysis is an exploratory multivariate statistical technique for simplifying complex data sets (Basilevsky, 1994; Warner, 2008). For example, given m observations on n variables, the goal of PCA is to reduce the dimensionality of the data matrix by finding a reduced number of p new variables, where p is fewer than n and these

p newly-constructed variables together account for as much of the variance in the original n variables as possible while remaining mutually uncorrelated and orthogonal. If we let the questions in the survey be X_1, X_2, X_3, …X_p , the PCA method generates components Z_1, Z_2, Z_3,…Z_p where each Z_i is a linear combination of the Xs, that is:

$$Z_1 = \sum_{i=1}^{p} a_{1i}X_i \ , \ Z_2 = \sum_{i=1}^{p} a_{2i}X_i \ ,\ldots\ Z_1 = \sum_{i=1}^{p} a_{pi}X_i \qquad \textbf{(A4.1)}$$

So that $Cov(Z_i, Z_j) = 0$ and $Var(Z_1) \geq Var(Z_2) \geq ... \geq, \ldots \geq Var(Z_p)$

for $i, j = 1, 2, \ldots, p$, $i \neq j$

In PCA, the Z_is are uncorrelated. The components hopefully describe different aspects of the data and it is hoped that a reduced number of the p components can be used to adequately describe the variation observed in the data; and the constants in (A4.1), a_{1i}, a_{2i}, etc. are the elements of the eigenvectors with constraints $\sum_{j=1}^{p} {a_{1j}}^2 = 1$ for Z_1**;** and similarly for each Z_p. The new variables Z_1, Z_2, …, Z_p are ordered by their variances. The corresponding eigenvalues, λ_i , i = 1,...p are the variances explained by the components where Z_1 has the largest eigenvalue λ_1 , Z_2 the next largest eigenvalue λ_2 , and so forth. The graph of the eigenvalues for the ordered components, Z_i, is shown in a Screeplot (p.227). Each constructed principal component is a linear combination of the original variables, and so it is often possible to ascribe meaning to what the constructed components represent. To determine the number of constructed components that must be retained in the model, the percentage of the explained variance accounted by the model is used as a criterion. In general, the percentage of the variance explained by the retained constructed components is required to be reasonably high, perhaps on the order of 40% to 70% (Warner, 2008:806). Before the PCA was carried out, the data were tested for adequate and high variability among the variables using Kaiser-Meyer-Olkin (KMO) statistics. The KMO statistics should be larger than 0.5 to proceed with the analysis (*ibid*). In addition, the Bartlett test was used on the presence of correlations among the variables and it was tested by a Chi-square test statistic. Accordingly, from the SPSS output (Table A4.2, p.225) the KMO measure of sampling adequacy (**= 0.828**), which is within the range of the required value to confirm high variability of the data; and the Bartlett[35] test produced a significant Chi-square value at $p < 0.000$ showing that the items are sufficiently correlated for PCA to be conducted.

Table A4.2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.828
Bartlett's Test of Sphericity	Approx. Chi-Square	2218.713
	Df	528
	Sig.	.000

The measurement scale used (Likert-scale) in the questionnaire was an ordinal scale. The emphasis of my investigation is to study the response pattern and an exploratory factor analysis procedure was employed, where the assumptions of normality and continuity could be relaxed. Based on the categories of the questions as given in the questionnaire (Appendix 3, p.218), I carried out three PCA procedures as follows:

- Procedure 1 – on the first 14 questions in categories I and II of the questionnaire (Appendix 3) where these questions focus on the perceived values and perceptions about mathematics;
- Procedure 2 – on the last 19 questions in categories III – V of the questionnaire where these questions focus on the perceived factors that promote successful learning of mathematics;
- Procedure 3 – on all the 33 questions of the questionnaire as one complete data set.

[35] This tests the pattern of the variances and co-variances between the variables in the model.

The analyses offered the following:

- Procedure 1 suggested a 5-component structure that explained 61.7% of the variation; KMO = 0.712; Determinant of Correlation Matrix = 0.06
- Procedure 2 suggested a 4- component structure that explained 55.8% of the variation; KMO = 0.877; Determinant of Correlation Matrix = 0.001
- Procedure 3 suggested an 8-component structure that explained 59.2% of the variation; KMO = 0.828; Determinant of Correlation Matrix = 0.00000293

After several considerations and looking at various indices (low determinant of the correlation, high KMO and relatively high variation explained) I decided to leave as many statements (variables) as possible and concentrate on the results obtained from Procedure 3. In addition this procedure enabled me to explore the relationship between the variables in sets I and II with those in sets III-V. For the collated data, the SPSS output from Procedure 3 is given in Table A4.3 (p.228) where the constructed components with their eigenvalues are shown.

An eigenvalue is the sum of the squares of the correlation, also known as ‘loadings’, between a measured variable and each of the extracted factors. When the eigenvalues for a component/factor is divided by the number of components it yields the proportion of the total variance accounted by the Component. Accordingly, for this investigation, 59.2% of the total variation is explained by the first eight extracted components, of which the first component accounts 12.82%, the second, 12.81%, the third 7.02%, the fourth 6.39%, the fifth 5.77%, the sixth 4.96%, the seventh 4.95% and the eighth 4.48% (Table A4.3, p.228).

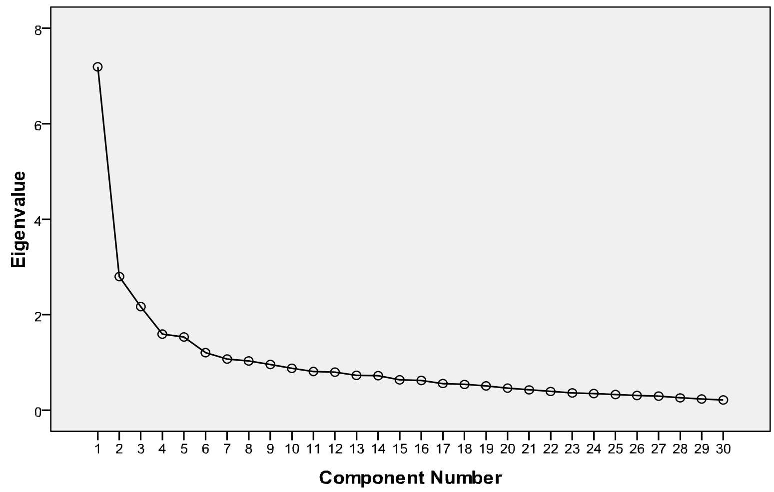


Figure A4.1: Scree Plot

Table A4.3: Eigenvalues – Sums of squared of the correlations

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.469	22.634	22.634	7.469	22.634	22.634	4.231	12.822	12.822
2	2.992	9.067	31.701	2.992	9.067	31.701	4.226	12.807	25.629
3	2.216	6.716	38.417	2.216	6.716	38.417	2.316	7.017	32.646
4	1.641	4.973	43.390	1.641	4.973	43.390	2.108	6.387	39.033
5	1.614	4.890	48.281	1.614	4.890	48.281	1.903	5.768	44.801
6	1.272	3.853	52.134	1.272	3.853	52.134	1.636	4.959	49.760
7	1.218	3.692	55.826	1.218	3.692	55.826	1.634	4.951	54.711
8	1.111	3.367	59.193	1.111	3.367	59.193	1.479	4.483	**59.193**
9	.997	3.022	62.215						
10	.975	2.954	65.169						
11	.914	2.769	67.938						
12	.875	2.652	70.590						
13	.813	2.464	73.054						
14	.736	2.231	75.285						
15	.715	2.167	77.453						
16	.703	2.129	79.582						
17	.669	2.028	81.610						
18	.586	1.777	83.386						
19	.574	1.738	85.125						
20	.503	1.525	86.650						
21	.476	1.441	88.091						
22	.453	1.372	89.463						
23	.444	1.346	90.810						
24	.410	1.242	92.052						
25	.385	1.167	93.220						
26	.355	1.076	94.296						
27	.336	1.018	95.314						
28	.309	.935	96.249						
29	.294	.891	97.140						
30	.288	.873	98.013						
31	.234	.708	98.721						
32	.212	.644	99.365						
33	.209	.635	100.000						

From the Scree[36] plot (Figure A4.1, p.227) and Table A4.3 (p.228), it can be seen that the eight components are extracted using the eigenvalues that are more than one. These eigenvalues are used to decide the number of components to be extracted and they are to be rotated in order to increase their interpretability in educational terms.

I used orthogonal rotation where the independence between the components is assumed and the Varimax[37] procedure in SPSS produced the result shown in Table A4.4 (p.232). However, the variables need to be sorted according to their loadings on the extracted components and then a selection and naming of the components made according to an established practical guideline. To be able to do this I used the guideline given by Hair, *et al*. (1998). That is, the cut-off loading value for a component to be significant and selected is 0.5, in absolute values. It is conceivable that two factor loadings across two components for a particular item are 0.5 or above; in this case I suggest dropping the variable with the lower factor loading from the analysis. After examining what the variables that load on a component have in common conceptually, appropriate naming of each of the extracted components is made as suggested below.

One assessment of how well the model extracted from the data explains the variation observed in the data can be obtained from the communalities (Table A4.5, p.233). The communalities can be thought of as R^2 in multiple regression models, where it shows the percentage of variation accounted by the fitted model. R^2 close to 1 indicates that the model explains most of the variation observed in the data. Accordingly, as seen in Table A4.5 (p.233), the communalities range from 0.750 - 0.412, implying that 75% to 41% of the variation observed in each of the 33 variables are explained by the eight extracted

[36] Scree plot is a plot in descending order of the sizes of the eigenvalues of a correlation matrix.
[37] Varimax procedure produces each factor to have a small number of large loadings and a large number of zero or near zero loadings (see Table A4.4).

components (Component 1 – Component 8). The variation observed in the strategy to be effective for learning mathematics variable, '*understanding basic concepts'*, (0.750 communality) is the best explained variable by the model while the variable '*memorising formulae*' (0.412 communality) has a relatively much lower proportion of predicted variance by the retained eight components implying that it has small loading with the extracted components. This however does not mean that *'memorising formulae'* as a strategy for effective learning was invalid; 63% of the respondents positioned it as an effective strategy for learning mathematics (Table A4.6, p.234). It is also noted that the model explains more than half of the variation exhibited for the majority of the variables with an overall variation of 59.2% and standard deviation of 0.0786, showing the adequacy of the statistical model.

A.3 Identification of the components constructed by PCA

All of the constructed components from the PCA do not map onto the issues I already noted during the interviews with members of the in-depth and focus groups. However I have used some of these components in the combined analyses as shown in Chapters Five - Seven. The extent of agreement of the respondents to the items in the questionnaire is given in Table A4.6, where the constructed components along with the percentage breakdown of the responses are summarized. Examining Tables A4.3 and A4.4, Component 1 accounts 12.82% out of the total 59.2% variation and it has moderate loadings, ranging from 0.734 to 0.574 on eight items, with the rest dropped or excluded according to the guideline adopted for this analysis. The eight items (variables) that highly load on Component 1 are agreed by the respondents to be the environment that stimulates the learning of mathematics, where a 69% - 90% rate of agreement about each of the variables is achieved from the respondents. The variables that constitute Component 1 are:

15. Having extra assistance (such as a tutor) available (3.88)[38]

16. Being in a class of students with similar ability (3.80)

17. A short lecture followed by a tutorial session (3.89)

18. Worked examples with exercises to solve (4.26)

19. *A lecture that works at my pace* (3.93)

20. The teaching techniques employed (4.01)

27. Seeking assistance at an early stage (4.12)

26. Attending classes regularly (4.23)

Putting the averages and the percentages together, it could be said that most of the respondents agree (average > 3) with the significance of the items isolated by Component 1 to stimulate their mathematics learning. I argue that Component 1 is a construct of the **general pedagogy that is learner-centred required for the learning of mathematics**.

[38] The averages in bracket indicate the interval of agreement for each of the variables that constitute the component constructed. Conventionally, an average value of below three roughly indicates that the majority of the participants tend to disagree with a statement, and an average above three that they tend to agree.

Table A4.4: Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
19.Lecture at my pace	**.734**	.018	.096	.058	.008	.026	.044	.105
20.Teaching techniques employed	**.671**	.284	.038	-.111	-.168	-.067	.119	-.033
16.A class of similar ability	**.657**	.100	.074	.049	-.122	-.063	.208	.148
17.Short lecture followed by tutorial	**.622**	.092	.222	.278	.048	.083	-.225	-.113
18.Worked examples with Exercises	**.614**	.268	.115	.106	-.269	.008	.057	-.274
15.Extra assistance	**.590**	.227	-.036	.089	.239	.218	.036	-.063
26.Attending classes regularly	**.580**	.553	.155	-.079	-.026	-.143	-.093	-.084
27.Seeking assistance at an early age	**.574**	.336	.215	-.124	.082	-.011	-.020	-.140
8.Use maths skills in day to day activities	.106	**.699**	-.048	.206	.006	-.245	-.102	-.067
9.maths stimulates thinking	.005	**.690**	-.068	.364	-.007	-.007	.043	-.049
23.Understanding basic concepts	.490	**.657**	.058	-.033	-.214	-.116	.017	-.118
24.Developing an interest	.253	**.612**	.120	.115	-.204	-.059	-.206	.016
22.Working hard at it	.311	**.610**	.104	.033	-.234	-.022	-.086	-.128
25.Relating maths to the real world	.304	**.559**	.192	-.042	-.025	-.016	-.105	.336
10.More employable	.240	**.521**	-.048	.483	-.016	-.132	.069	-.067
28.Learner's natural ability	.090	-.130	**.745**	.129	-.074	-.006	.157	.052
30.Learner's past experience	.265	.030	**.675**	-.020	.142	-.038	-.063	.294
31.Support from family	.047	.054	**.641**	.098	.138	.036	.037	-.027
29.Learner's attitude	.102	.447	**.558**	-.053	-.209	.178	.134	-.257
33.Learner's self confidence	.154	.434	**.532**	-.034	-.076	-.008	.253	-.129
12.Respect if study maths	-.078	.157	.109	**.772**	.133	.220	-.007	.005
13.Good in maths are successful in life	.025	.046	.108	**.751**	-.044	-.002	.226	.185
11.C grade in maths for entry to University	.395	.175	.032	**.504**	-.235	-.134	.075	-.038
14.Importance of maths overstated	.086	-.183	.014	.035	**.696**	-.071	-.023	.104
7.Perception shaped by others	-.195	.009	.038	-.024	**.586**	.267	.112	.084
1.Maths is difficult	.085	-.127	.081	-.207	**.517**	.378	.354	-.133
21.memorising formulae	.240	.392	-.069	-.056	-.421	.074	.018	.097
6.Teachers said maths is difficult	-.118	-.067	.045	.017	.166	**.779**	-.127	-.031
5.Parents think maths is difficult	.157	-.190	-.004	.091	-.039	**.693**	.083	.056
3.Mental apttitude required to do maths	.150	-.091	.126	.112	-.059	-.036	**.680**	.097
4.Some ethnic groups are better in maths	.022	-.115	.124	.138	.263	-.010	**.655**	.006
32.Learners gender	-.046	-.274	.039	.097	.156	-.063	.012	**.711**
2.Male students more likely to be successful	-.144	.223	.029	.071	-.106	.199	.459	**.632**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 11 iterations.

Table A4.5: Communalities (Extraction Method: Principal Component Analysis)

Variables	Initial	Extraction
1. Maths is difficult	1.000	.626
2. Male students more likely to be successful	1.000	.737
3. Mental aptitude required to do maths	1.000	.535
4. Some ethnic groups are better in maths	1.000	.546
5. Parents think maths is difficult	1.000	.561
6. Teachers said maths is difficult	1.000	.672
7. Perception shaped by others	1.000	.474
8. Use maths skills in day to day activities	1.000	.619
9. maths stimulates thinking	1.000	.617
10. More employable	1.000	.591
11. C grade in maths for entry to Uni	1.000	.522
12. Respect if study maths	1.000	.705
13. Good in maths are successful in life	1.000	.666
15. Extra assistance	1.000	.519
16. A class of similar ability	1.000	.534
17. Short lecture followed by tutorial	1.000	.595
18. Worked examples with Exercises	1.000	.624
19. Lecture at my pace	1.000	.565
20. Teaching techniques employed	1.000	.592
22. Working hard at it	1.000	.560
23. Understanding basic concepts	1.000	.750
24. Developing an interest	1.000	.555
25. Relating maths to the real world	1.000	.568
26. Attending classes regularly	1.000	.709
27. Seeking assistance at an early age	1.000	.531
28. Learner's natural ability	1.000	.630
29. Learner's attitude	1.000	.684
30. Learner's past experience	1.000	.640
31. Support from family	1.000	.448
33. Learner's self confidence	1.000	.583
14. Importance of maths overstated	1.000	.543
21. memorising formulae	1.000	.412
32. Learners gender	1.000	.623

Table A4.6: The responses (in %) of the respondents for each statement (variable)

Variables (items) as in the Questionnaire	Agree	Dis-agree	Constructed component (with %variation explained)
15.Having extra assistance (such as a tutor) available help stimulate my mathematics learning	70	8	(1)PEDAGOGY **(12.82%)**
16.Being in a class of students with similar ability help stimulate my mathematics learning	69	13	
17.A short lecture followed by a tutorial session help stimulate my mathematics learning	74	8	
18.Worked examples with exercises to solve help stimulate my mathematics learning	90	7	
19.A lecture that works at my pace help stimulate my mathematics learning	76	7	
20.The teaching techniques employed help stimulate my mathematics learning	78	4	
26.Attending classes regularly is effective strategy for learning mathematics	84	5	
27.Seeking assistance at an early age is effective strategy for learning mathematics	81	7	
9.Studying mathematics stimulates my thinking, creativity and abstraction	69	13	(2)ATTITUDE/ BELIEF TOWARDS THE SUBJECT (**12.81**%)
10.Studying mathematics will make me more employable and help in my career	76	6	
22.Working hard at it and solving as many problems as possible is effective strategy for learning mathematics	80	7	
23.Understanding basic concepts is effective strategy for learning mathematics	89	5	
24.Developing an interest in mathematics is effective strategy for learning mathematics	71	10	
25.Relating mathematics skills to the real world is effective strategy for learning mathematics	69	7	
8.Learning mathematics is important because I use the skills I learn in my day to day activities	71	15	
28.The learner's natural ability to do mathematics affect the successful learning of mathematics	51	16	(3)BELIEF RELATED TO THE LEARNER **(7.02%)**
30.The learner's past experience of mathematics affect the successful learning of mathematics	51	21	
31.Support and encouragement of learning mathematics from your family affect the successful learning of mathematics	48	21	
29.The learner's attitude & motivation towards mathematics affect the successful learning of mathematics	81	4	
33.Learner's self confidence and belief regarding mathematics affect the successful learning of mathematics	71	8	
11.Achieving C or a better grade in GCSE/A-levels mathematics should be a general entry requirement into universities	68	16	(4) BELIEF ABOUT MATHEMATICS **(6.39%)**
12.My friends and family will respect me if I am successful at mathematics	32	40	
13.People who are good at mathematics are successful in life	28	30	

Variables (items) as in the Questionnaire	Agree	Dis-agree	Constructed component (with %variation explained)
1.Mathematics is a difficult subject	39	46	(5)PERCEPTION OF MATHEMATICS **(5.77%)**
7.My current perception of mathematics has probably been shaped by what others say about mathematics	20	58	
14.The importance given to mathematics in society is overstated	24	34	
5.People close to me, including my parents, think (or thought) mathematics to be a difficult subject	47	36	(6)PERCEPTION OF MATHEMATICS BY OTHERS **(4.96%)**
6.When I was younger my teachers said mathematics is a difficult subject.	28	52	
3.One needs particular mental aptitudes to be able to do mathematics	46	24	(7)ETHNICITY OF THE LEARNER **(4.95%)**
4.It is likely that some ethnic groups are better at mathematics than others	32	48	
32.The learner's gender affects the successful learning of mathematics	7	73	(8)THE GENDER OF THE LEARNER **(4.48%)**
12.Mathematics is a subject in which male students are more likely to be successful	17	55	
21.Memorizing formulae is effective for learning mathematics	63	18	INDEPENDENT

Component 2 accounts 12.81% out of the total variation, and its moderate loadings range from 0.699 - 0.559. It is highly loaded by the following seven variables agreed by the respondents to be effective strategies for the learning of mathematics, where the agreement rate for each variable is 69% - 89%.

22. *Working hard and solving as many problems as possible* (4.14)

24. *Developing an interest in mathematics* (3.87)

25. *Relating mathematics skills to the real world* (3.78)

8. *Learning mathematics is important because I use the skills I learn in my day to day activities (3.80)*

9. *Studying mathematics stimulates my thinking, creativity and abstraction* (3.78)

23. Understanding basic concepts (4.29)

10. Studying mathematics will make me more employable and help in my career (3.95)

The seven variables that make up Component 2 are attitudes and beliefs of the respondents that learners should have in order to be successful in the learning of mathematics (average >3). Thus, learners of mathematics need to position themselves not only as novices but as seekers of mathematical knowledge by developing their interest, understanding basic concepts and relating mathematics skills in their day-to-day activities and relating to the opportunities made available through it. I argue that Component 2 is a construct of the **attitude and belief of the learners towards mathematics learning**.

Components 1 and 2 are the two major contributors towards accounting the variability in the data; a little over 25% of the variation is explained jointly by the two Components. Accordingly, 'a learner-friendly pedagogy' and 'the right attitude and belief for learning of mathematics' are the two most important constructed components the respondents agreed affected their learning, positively or negatively, depending on the presence or absence of the variables.

Component 3 accounts 7.02 % out of the total variation, and its moderate loadings range from 0.745 to 0.641, with the following five variables agreed by the respondents to affect the successful learning of mathematics. These load significantly on Component 3 where the agreement rate to each variable is 48% - 71%**.**

28.The learner's natural ability to do mathematics (3.53)

30. The learner's past experience of mathematics (3.44)

31. Support and encouragement of learning mathematics from your family (3.33)

29. Learner's attitude and motivation towards mathematics (4.14)

33. The learner's self-confidence and belief regarding mathematics (3.90)

Looking at the percentages and the average values, the majority of the respondents agreed the elements of Component 3 contribute to the learning of mathematics. I argue that Component 3 is a construct of **belief to the learning of mathematics**. The respondents agreed in learners inheriting a natural ability from their biological parents and that this could be made to play a role in reinforcing the learning of mathematics.

The percentage of variation explained by each of the remaining five components is getting smaller ranging from 6.39% to 4.48% . If the emphasis of the research was on dimension reduction of the data the first three components would have been sufficient (this is also obvious from the Screeplot, p.227). However these five components have educational significance in my research and have been included in the analysis. Accordingly, Component 4 accounts 6.39% out of the total variation and its moderate loadings range from 0.772 to 0.504 where the agreement rate for each variable is 28% - 68%. The variables are:

11 Achieving C or a better grade in GCSE/A-levels mathematics should be a general entry requirement into universities (3.81)

12 My friends and family will respect me more if I am successful at mathematics (2.89)

13 People who are good at maths are successful in life (2.99)

The respondents have diverse views about the items making up Component 4. A majority of the respondents disagree with the contents of the last two items (where the average < 3) and agree with the first item in the list. It is noted that one of the average values, 2.99, is very close to be neutral; however it is to be recalled that the average values indicate interval scales. Hence the average 2.99 indicates the scale between 2 and 3 (more likely to be an indication of disagreement). The number of items that enabled the construction of Component 4 is small, however. Examining the items closely indicates that they are related to the beliefs learners have regarding the status of mathematics. Hence Component 4 is retained in my analysis as representing the conceptualization of the **learners' beliefs about the status of mathematics**.

Component 5 accounts 5.77% out of the total variation, and its moderate loadings range from 0.696 to 0.517 with low agreement rate of 20% - 39%. The variables are:

1 *Mathematics is a difficult subject* (2.97)

7 *My current perception of mathematics has probably been shaped by what others say about mathematics* (2.44)

14 *The importance given to mathematics in society is overstated* (2.90)

Again, looking at the average values in brackets, it appears that the respondents do not agree with these stereotypical contents of the items about the perceptions and status of mathematics. One can cautiously say that there is indication of a change of learners' perceptions or diversified views about mathematics taking place among some of the mathematics first year students under my investigation. Looking at Table A4.6, the high 'undecided' percentage for this category of variables, coupled with the small number of components involved, to construct Component 5 makes its identification unclear. However, examining the items closely indicates that they are related to how mathematics is perceived by learners. Hence, I argue that Component 5 represents the conceptualization of the **learner's perception of mathematics**.

Each of the following three factors was constructed from small number of variables as shown. Moreover, Component 6 explains 4.96% out of the total variation and the agreement rate is 28% - 47% and its two variables are:

5 *People close to me, including my parents, think (or thought) mathematics to be a difficult subject* (3.15)

6 *When I was younger, my teachers said that mathematics is a difficult subject* (2.68)

This component may be conceptualized as the **perception of mathematics by people close to the learner**, such as family members and teachers.

Component 7 accounts 4.95% out of the total variation with an agreement rate of 32% - 45% and its variables are:

3 *One needs particular mental aptitudes to be able to do mathematics* (3.27)

4 *It is likely that some ethnic groups are better at mathematics than others* (2.79)

This component may be conceptualized as characteristics that learners must possess on the basis of their **ethnicity.**

Component 8 accounts 4.48% out of the total variation with less than 16% agreement rate and its variables are:

32 *The learner's gender affects the successful learning of mathematics* (1.83)

2 *Mathematics is a subject in which male students are more likely to be successful* (2.40)

This component may be conceptualized as issues related to the **gender of the learner.** The averages indicate that the respondents did not agree that the gender of the learner affected their learning of mathematics.

For the statistical consistency reliability analysis of all the variables identified by the PCA generated KMO = 0.772, a significant Bartlett's value = 1470.251 and Cronbach's alpha index of 0.739, which shows that variables that optimize the index are included implying the statistical validity of the questionnaire to be used as a measuring instrument.

A.4 GLM Analysis

The effect of the explanatory attributes of the respondents (age, gender, etc.) on the Components constructed from the Principal Component Analysis is explored using General Linear Models (GLM) analysis. General Linear Model is a statistical model in which one or more explanatory variables (categorical or continuous) are used to predict outcomes on one outcome ('dependent' or 'response') variable. The explanatory attributes of the respondents are here categorical (Table A4.7, p.243). The so-called Scores generated by the Principal Component Analysis and obtainable from SPSS output are, saved and here used as dependent (response) variables. The Scores indicate the value of a component from low (negative values) to high (positive values). Since significant tests depend on the normality assumption, preliminary data screening was done to assess whether the assumptions for GLM was seriously violated by the eight Scores obtained from the PCA. Examination of normality tests on the Scores suggested that Component 2, which is the construct of Attitude, mildly violated the normality test. I used a Square-root transformation on the Scores to correct the normality assumption which produced a normally distributed data set. The Levene test on the Scores indicated no significant violation of the homogeneity of the variances.

The estimated saturated GLM model, for example, using two independent variables of levels k and m, and S as dependent variable is of the form:

$$\widehat{S_{ij}} = \hat{\mu}_0 + \hat{\alpha}_i + \hat{\beta}_j + (\widehat{\alpha\beta})_{ij} \quad \textbf{(A4.2)}$$

where i = 1, 2, …k; and j = 1,2, …m;

and the parameter estimates are obtainable from the SPSS output. The GLM procedure available in SPSS was implemented using the explanatory/categorical variables given in Table A4.7. Since the number of participants in all categories was not equal I had to follow the Forward Selection strategy of fitting the variables into the model (A4.2):

- Start with one of the four main effects (age, gender, ethnicity and Area of Study);
- Choose one of the remaining three main effects and fit the two main effects; test for the significance of the main effects;
- Retain the main effect in the model that is significant; otherwise it is dropped and the remaining two main effects are fitted one at a time checking the significance of the main effects at each stage of the model fitting;
- If two main effects are significant then the two way interaction is fitted and tested; the interaction is retained in the model if it is significant otherwise it is dropped;
- Similar procedure is followed for fitting the 3-way and 4-way interactions.
- At each stage of the model fitting exercise non-significant terms are dropped from the model.

The result from the procedure of the model building on the eight Scores obtained from the PCA analysis is given in Tables A4.9- A4.15 (pp. 246 - 262).

The categorical variables that were shown to be significant by the GLM analysis were used to assess their impact on the **responses** of the students to the survey questions.

Table A4.7 The variables used in the model building

Categorical Variables	Label with (Number in the category)
Gender (G)	1= male(92); 2 = female (95)
Ethnicity (E)	1 = White(64); Mixed and other (26); 3 = Asian(45); 4 = Black(52) [Has been reduced to binary as required]
Area Study(C)	1=Business (80); 2 = Biomedical (51); 3 = Maths (56) [Has been reduced to binary as required]
Age (A)	1 = ≤20 (77); 2 = 21-25(71); 3 = 26-30(19); 4 = 31- 40(13); 5= >40(7) [Has been reduced to binary as required]

A.5 Logistic Regression Analysis

A class of models closely related to GLM is Logistic Regression models. Logistic Regression is often used to analyse data for which the outcome variable is categorical and binary. Logistic Regression can be used for the prediction of a group membership or, more generally, for understanding and interpretation of the relationship between a response and explanatory variables and or 'factors'[39]. It involves evaluating the odds of different outcomes. In this analysis I have applied Logistic Regression on the response variables (responses of the participants in binary form to each of the survey questions) and the four variables of interest (the explanatory factors age, A; gender, G; ethnicity, E; and course (Area of Study), C). Let the response variable be Y with responses 0 = disagree and 1 = agree. Then for all main effects the model is:

$\boldsymbol{ln}\left(\frac{p}{1-p}\right)$ where p = P(Y=1) = probability of belonging to the

[39] A factor in Logistic Regression context is a nominal/ categorical explanatory variable.

success group and $\boldsymbol{ln}\left(\frac{\hat{p}}{1-\hat{p}}\right) = \hat{\eta}_{ijkl} = \hat{b} + \begin{Bmatrix} \hat{A}_1 \; if \; i = 1; \\ \hat{A}_2 \; if \; i = 2 \\ \hat{A}_3 \; if \; i = 3 \\ \hat{A}_4 \; if \; i = 4 \\ 0 \; if \; i = 5 \end{Bmatrix} +$

$$\begin{Bmatrix} \hat{G}_1 \; if \; j = 1 \\ 0 \; if \; j = 2 \end{Bmatrix} + \begin{Bmatrix} \hat{E}_1 \; if \; k = 1 \\ \hat{E}_2 \; if \; k = 2 \\ \hat{E}_3 \; if \; k = 3 \\ 0 \; if \; k = 4 \end{Bmatrix} + \begin{Bmatrix} \hat{C}_1 \; if \; l = 1 \\ \hat{C}_2 \; if \; l = 2 \\ 0 \; if \; l = 3 \end{Bmatrix}$$

The predicted probability for a membership of a group could be calculated using

$$\hat{p} = \frac{e^{\hat{\eta}}}{1+e^{\hat{\eta}}} = \frac{1}{1+e^{-\hat{\eta}}} \qquad \textbf{(A4.3)}$$

The Odds Ratio in favour of a group agreeing/disagreeing to the response variable leaving other factors the same (*ceteris paribus*) could also be worked from $\mathbf{e^{bi}}$ where b_i is the regression coefficient of the desired explanatory variable from the fitted model. Since the parameter estimates are not orthogonal, a procedure for adding the explanatory variables into the model has to be selected. I have followed the method of Forward Selection Logistic Regression analysis of fitting the explanatory variables using the following strategy: in the first step, tests have to be carried out on each of the four main effects (A, G, E, and C); then any significant two-way interactions for the significant main effects are added; and so forth for the three-way and four-way interactions, always confining ourselves to hierarchical models. I have used the difference Log-likelihoods to test the significance of the explanatory factors in the fitted models. The probabilities and the Odds Ratios available from the model fitted by SPSS are used to update the results from the GLM analysis when assessing the impact of the categorical variables on the responses of the students to the survey questions. The result from the Logistic Regression analysis is given in Tables A4.16- A4.31 (pp.264 - 274).

The results from the quantitative analyses are integrated with the themes obtained from the thematic analysis of the qualitative data as demonstrated in Section 4.4 (p.88) to help answer the main research question given in Section 1.3 (p. 13).

Tables

The tables from the SPSS analyses that were quoted in the thesis are given below.

Table A4.9 Analysis of Score of Component 1

(a) Gender and Age

Between-Subjects Factors

		Value Label	N
Gender	1	male	92
	2	female	95
Age	1	20 or below	77
	2	21-25	71
	3	26-30	19
	4	31-40	13
	5	41 or over	7

2. Gender

Dependent Variable: REGR Component Score 1

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
male	-.069	.126	-.317	.179
female	.180	.135	-.086	.447

3. Age

Dependent Variable: REGR Component Score 1

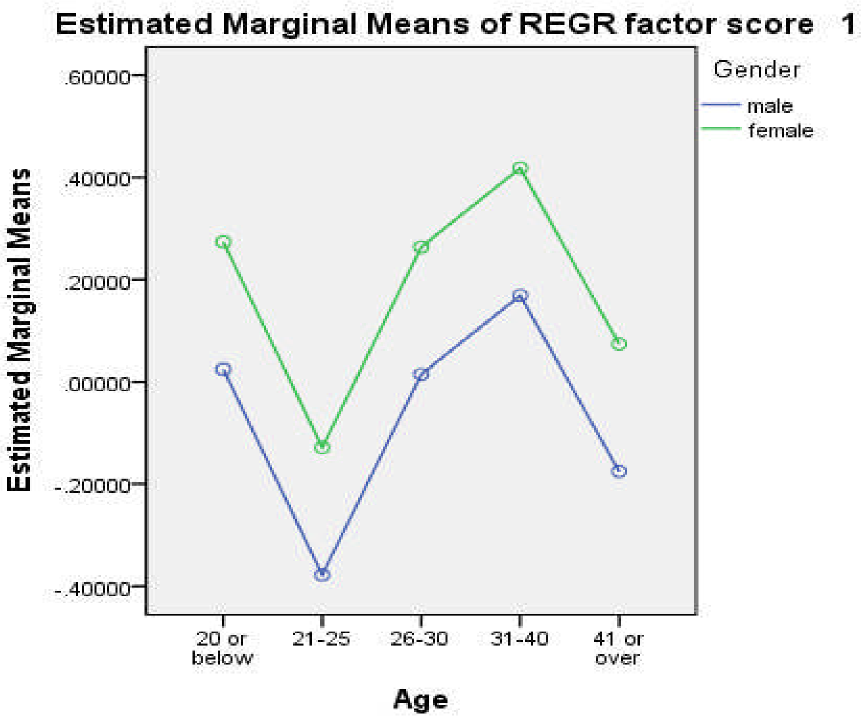
Age	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
20 or below	.149	.112	-.072	.371
21-25	-.253	.117	-.484	-.022
26-30	.139	.226	-.307	.585
31-40	.294	.273	-.245	.833
41 or over	-.051	.376	-.793	.691

Parameter Estimates

Dependent Variable: REGR factor score 1 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	.074	.393	.188	.851	-.701	.849
[Gender=1]	-.249	.146	-1.710	.089	-.537	.038
[Gender=2]	0[a]	.	.	.	.	.
[Age=1]	.200	.392	.510	.611	-.574	.974
[Age=2]	-.202	.395	-.513	.609	-.981	.576
[Age=3]	.190	.438	.434	.665	-.674	1.055
[Age=4]	.345	.465	.740	.460	-.574	1.263
[Age=5]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.



(b) Age and Ethnicity

2. Age

Dependent Variable: REGR Component S score 1

Age	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
20 or below	.125	.116	-.104	.355
21-25	-.317	.120	-.554	-.079
26-30	.054	.231	-.402	.509
31-40	.161	.289	-.409	.732
41 or over	-.256	.376	-.998	.486

3. Mixed and Chinese merged

Dependent Variable: REGR Component Score 1

Mixed and Chinese merged	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Whiite (British, Irish, other White)	.141	.159	-.173	.455
Other(Mixed & Chinese merged together)	-.392	.215	-.816	.032
Asianor Asian British (Pakistani, Bangladeshi, Any Other Asian)	-.084	.184	-.447	.279
Black or Black British (Caribbean,African, Any Other Black)	.149	.145	-.137	.436

Tests of Between-Subjects Effects

Dependent Variable: REGR Component Score 1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14.022[a]	7	2.003	2.085	.047
Intercept	.158	1	.158	.164	.686
ReducedEthn	6.481	3	2.160	2.249	.084
Age	8.416	4	2.104	2.190	.072
Error	171.978	179	.961		
Total	186.000	187			
Corrected Total	186.000	186			

a. R Squared = .075 (Adjusted R Squared = .039)

Parameter Estimates

Dependent Variable: REGR factor score 1 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	-.060	.379	-.158	.874	-.808	.688
[Age=1]	.381	.396	.962	.337	-.401	1.164
[Age=2]	-.061	.393	-.155	.877	-.836	.714
[Age=3]	.310	.434	.713	.476	-.547	1.166
[Age=4]	.417	.464	.899	.370	-.498	1.333
[Age=5]	0[a]	.	.	.	.	.
[ReducedEthn=1.00]	-.009	.197	-.043	.965	-.397	.380
[ReducedEthn=2.00]	-.542	.246	-2.201	.029	-1.028	-.056
[ReducedEthn=3.00]	-.233	.215	-1.085	.279	-.657	.191
[ReducedEthn=4.00]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

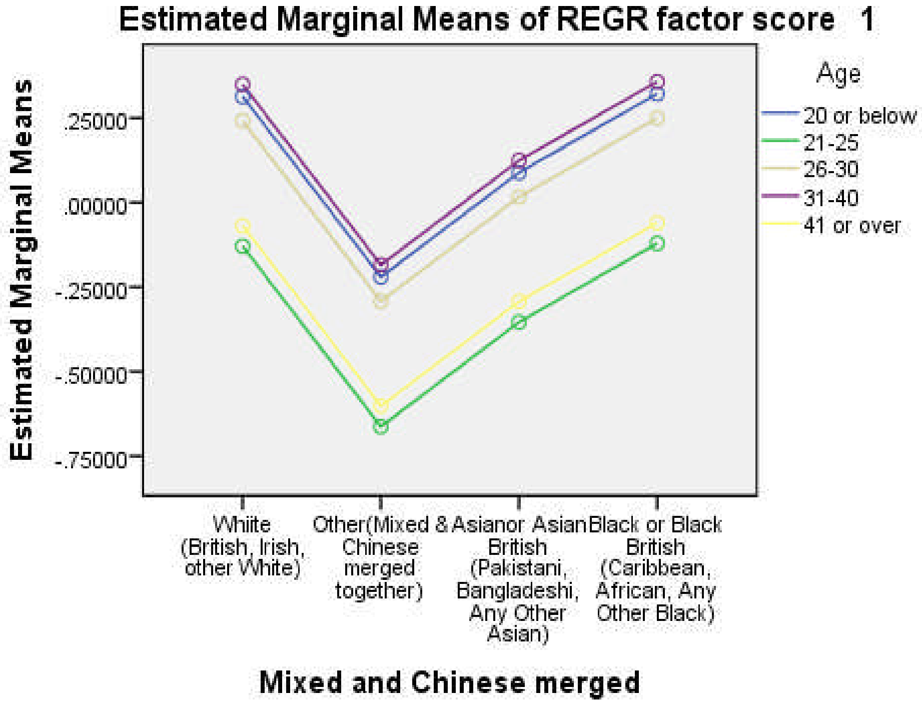


Table A4.10 Analysis of Score of Component 3

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.869[a]	4	2.717	2.824	.026
Intercept	.124	1	.124	.128	.721
ReducedEthn	10.567	3	3.522	3.660	.014
Gender	.853	1	.853	.886	.348
Error	175.131	182	.962		
Total	186.000	187			
Corrected Total	186.000	186			

Parameter Estimates

Dependent Variable: REGR factor score 3 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	.115	.155	.740	.460	-.192	.422
[Gender=1]	-.136	.145	-.941	.348	-.421	.149
[Gender=2]	0[a]	.	.	.	.	.
[ReducedEthn=1.00]	-.189	.184	-1.027	.306	-.551	.174
[ReducedEthn=2.00]	-.418	.236	-1.770	.078	-.884	.048
[ReducedEthn=3.00]	.310	.200	1.551	.123	-.084	.705
[ReducedEthn=4.00]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

3. Mixed and Chinese merged

Dependent Variable: REGR factor score 3 for analysis 1

Mixed and Chinese merged	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Whiite (British, Irish, other White)	-.142	.123	-.384	.101
Other(Mixed & Chinese merged together)	-.371	.193	-.751	.009
Asianor Asian British (Pakistani, Bangladeshi, Any Other Asian)	.357	.147	.068	.646
Black or Black British (Caribbean,African, Any Other Black)	.047	.136	-.222	.315

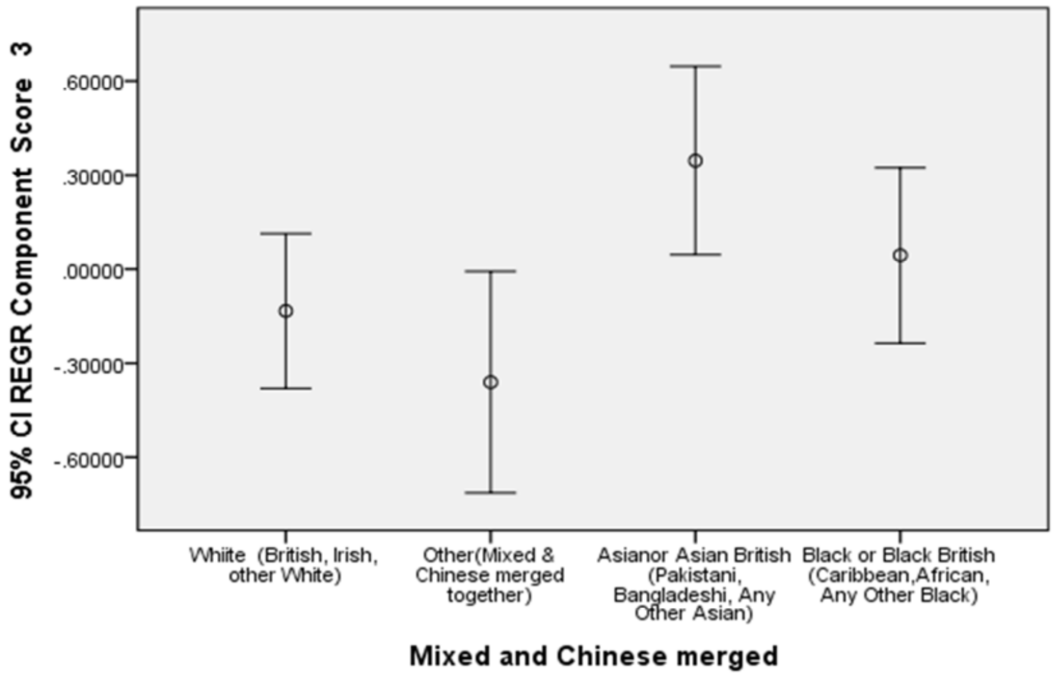


Table A4.11 Analysis of Score of Component 4

Tests of Between-Subjects Effects

Dependent Variable: REGR Component Score 4

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.242[a]	3	2.081	2.118	.099
Intercept	.044	1	.044	.044	.833
AreaStudy	6.021	2	3.010	3.065	.049
Gender	.326	1	.326	.332	.565
Error	179.758	183	.982		
Total	186.000	187			
Corrected Total	186.000	186			

a. R Squared = .034 (Adjusted R Squared = .018)

Parameter Estimates

Dependent Variable: REGR factor score 4 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	.227	.154	1.479	.141	-.076	.530
[AreaStudy=1]	-.140	.173	-.807	.421	-.481	.202
[AreaStudy=2]	-.463	.192	-2.412	.017	-.842	-.084
[AreaStudy=3]	0[a]	.	.	.	.	.
[Gender=1]	-.084	.145	-.577	.565	-.370	.203
[Gender=2]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Estimates

Dependent Variable: REGR Component Score 4

AreaStudy	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
business	.048	.111	-.170	.266
science with no maths	-.275	.139	-.549	-.002
maths	.182	.132	-.078	.443

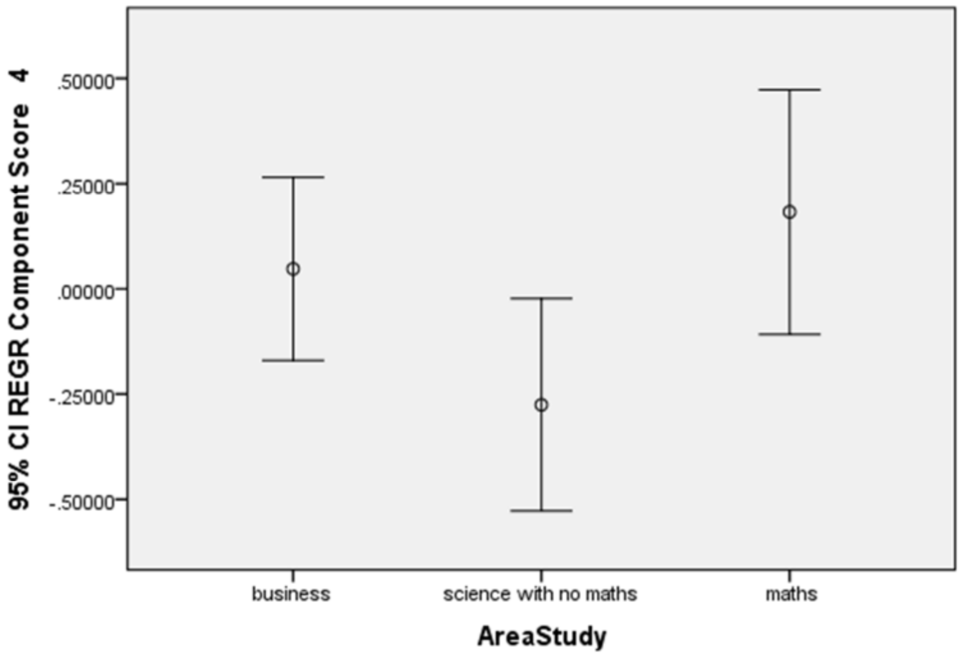


Table A4.12 Analysis of Score of Component 5

Age and Ethnicity

2. Age

Dependent Variable: REGR Component Score 5

Age	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
20 or below	.114	.115	-.114	.341
21-25	-.071	.119	-.305	.164
26-30	-.169	.228	-.619	.281
31-40	.589	.286	.025	1.153
41 or over	-.608	.372	-1.343	.126

3. Mixed and Chinese merged

Dependent Variable: REGR Component Score 5

Mixed and Chinese merged	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Whiite (British, Irish, other White)	-.254	.157	-.564	.057
Other(Mixed & Chinese merged together)	.059	.212	-.360	.478
Asianor Asian British (Pakistani, Bangladeshi, Any Other Asian)	-.180	.182	-.538	.179
Black or Black British (Caribbean,African, Any Other Black)	.258	.144	-.026	.541

Tests of Between-Subjects Effects

Dependent Variable: REGR Component Score 5

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17.796[a]	7	2.542	2.705	.011
Intercept	.062	1	.062	.066	.798
Age	8.671	4	2.168	2.307	.060
ReducedEthn	7.402	3	2.467	2.626	.052
Error	168.204	179	.940		
Total	186.000	187			
Corrected Total	186.000	186			

a. R Squared = .096 (Adjusted R Squared = .060)

Parameter Estimates

Dependent Variable: REGR factor score 5 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	-.664	.465	-1.429	.155	-1.581	.253
[Age=1]	.698	.398	1.756	.081	-.087	1.483
[Age=2]	.547	.394	1.388	.167	-.231	1.324
[Age=3]	.317	.440	.719	.473	-.553	1.186
[Age=4]	1.174	.464	2.531	.012	.258	2.090
[Age=5]	0[a]	.	.	.	.	.
[Ethnicity=1]	-.150	.334	-.449	.654	-.808	.509
[Ethnicity=2]	.437	.451	.969	.334	-.454	1.328
[Ethnicity=3]	-.083	.345	-.242	.809	-.765	.598
[Ethnicity=4]	.369	.345	1.068	.287	-.313	1.050
[Ethnicity=5]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

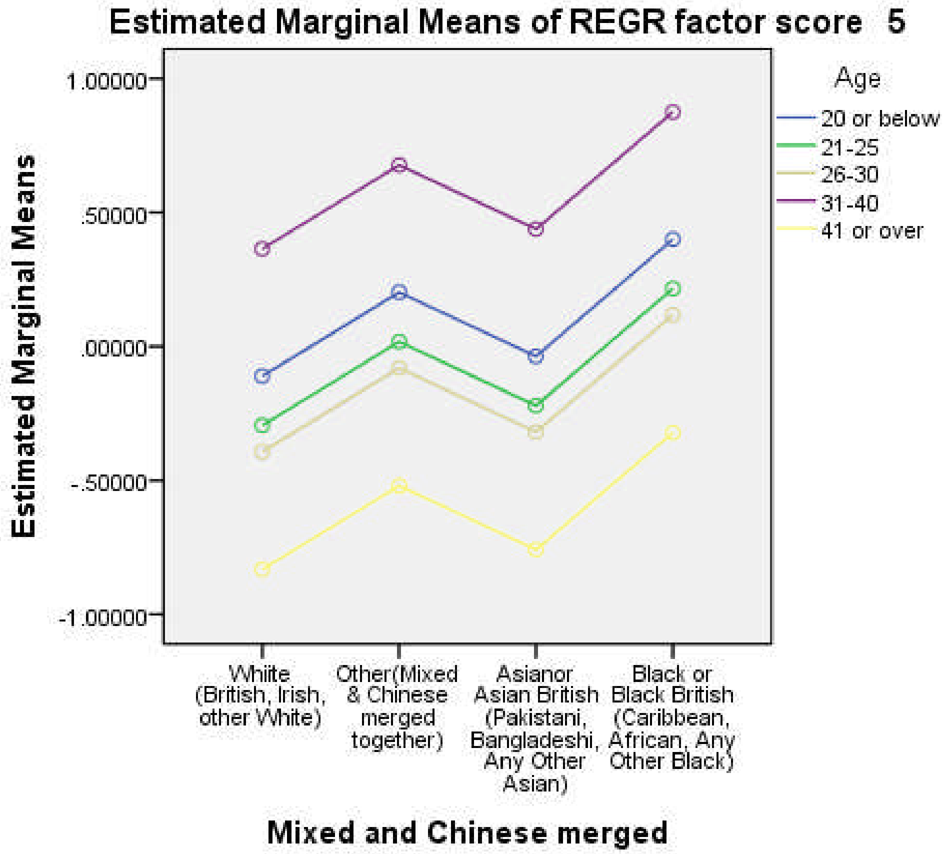


Table A4.13 Analysis of Score of Component 6

(a) **Gender and Area of Study**

2. Gender

Dependent Variable: REGR Component Score 6

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
male	.155	.103	-.048	.358
female	-.107	.102	-.308	.093

3. AreaStudy

Dependent Variable: REGR Component Score 6

AreaStudy	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
business	-.162	.109	-.378	.053
science with no maths	-.061	.137	-.331	.209
maths	.295	.131	.037	.553

Tests of Between-Subjects Effects

Dependent Variable: REGR Component Score 6

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.902[a]	3	3.634	3.798	.011
Intercept	.101	1	.101	.106	.745
Gender	3.202	1	3.202	3.346	.069
AreaStudy	7.139	2	3.570	3.731	.026
Error	175.098	183	.957		
Total	186.000	187			
Corrected Total	186.000	186			

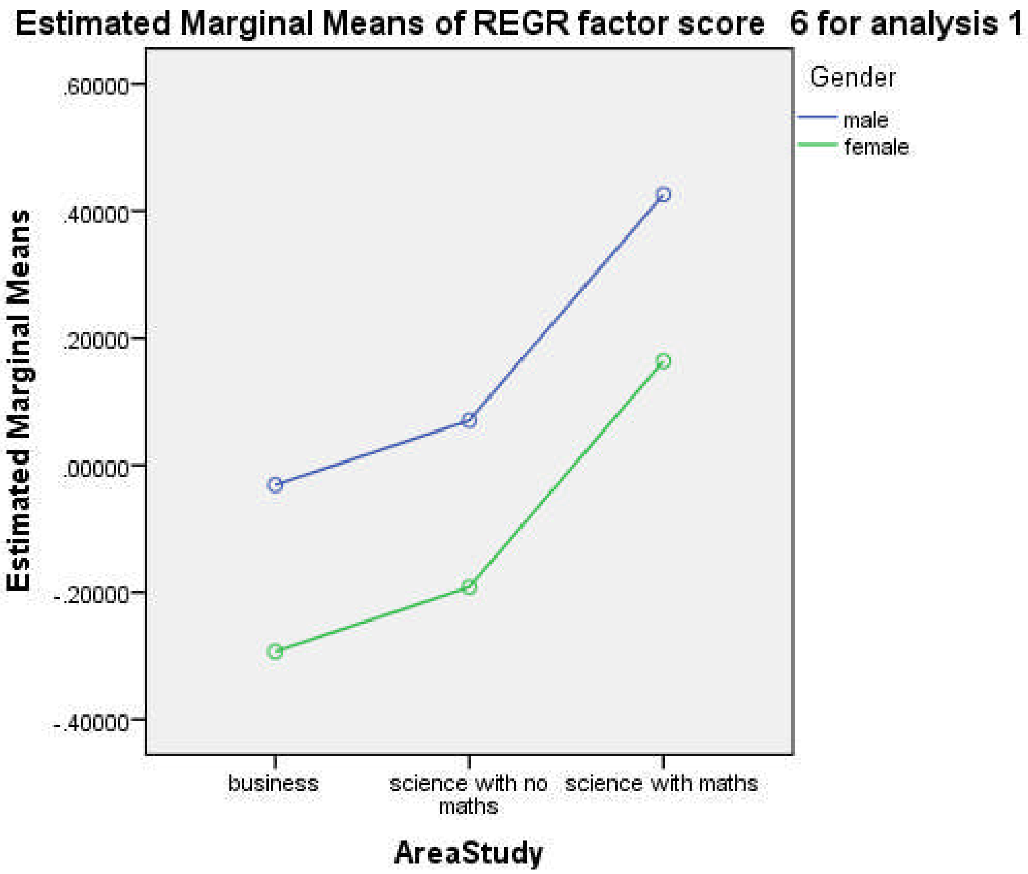
a. R Squared = .059 (Adjusted R Squared = .043)

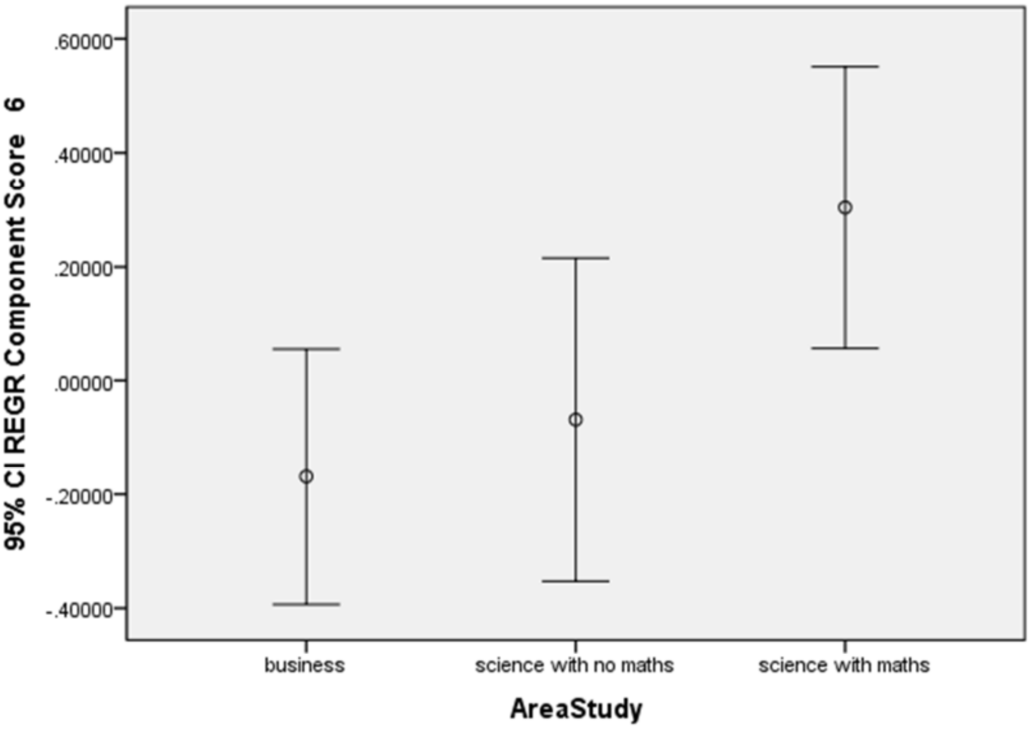
Parameter Estimates

Dependent Variable: REGR factor score 6 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	.164	.152	1.079	.282	-.136	.463
[Gender=1]	.262	.143	1.829	.069	-.021	.545
[Gender=2]	0[a]	.	.	.	.	.
[AreaStudy=1]	-.457	.171	-2.678	.008	-.794	-.120
[AreaStudy=2]	-.356	.190	-1.876	.062	-.730	.018
[AreaStudy=3]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.





Multiple Comparisons

Dependent Variable: REGR factor score 6 for analysis 1

LSD

(I) AreaStudy	(J) AreaStudy	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
business	science with no maths	-.1003443	.17527530	.568	-.4461645	.2454760
	science with maths	-.4729930*	.17042983	.006	-.8092531	-.1367329
science with no maths	business	.1003443	.17527530	.568	-.2454760	.4461645
	science with maths	-.3726487	.18933371	.051	-.7462064	.0009090
science with maths	business	.4729930*	.17042983	.006	.1367329	.8092531
	science with no maths	.3726487	.18933371	.051	-.0009090	.7462064

Based on observed means.

The error term is Mean Square(Error) = .957.

*. The mean difference is significant at the .05 level.

(b) When only Area of Study is fitted

Tests of Between-Subjects Effects

Dependent Variable: REGR Component Score 6

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.700[a]	2	3.850	3.973	.020
Intercept	.088	1	.088	.091	.764
AreaStudy	7.700	2	3.850	3.973	.020
Error	178.300	184	.969		
Total	186.000	187			
Corrected Total	186.000	186			

a. R Squared = .041 (Adjusted R Squared = .031)

Parameter Estimates

Dependent Variable: REGR factor score 6 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	.304	.132	2.311	.022	.044	.564
[AreaStudy=1]	-.473	.172	-2.758	.006	-.811	-.135
[AreaStudy=2]	-.373	.191	-1.956	.052	-.749	.003
[AreaStudy=3]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

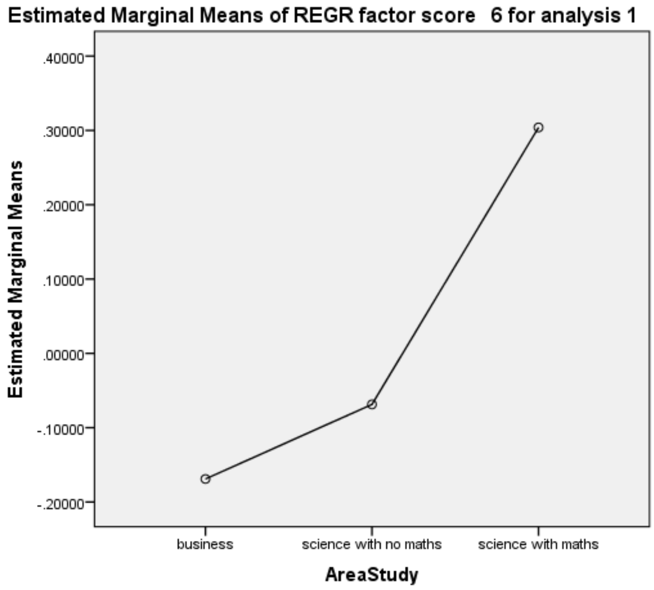


Table A4.14 Analysis of Score of Component 7

Tests of Between-Subjects Effects

Dependent Variable: REGR Component Score 7

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.147[a]	3	4.382	4.640	.004
Intercept	.005	1	.005	.006	.940
Gender	12.609	1	12.609	13.350	.000
AreaStudy	.814	2	.407	.431	.651
Error	172.853	183	.945		
Total	186.000	187			
Corrected Total	186.000	186			

a. R Squared = .071 (Adjusted R Squared = .055)

Parameter Estimates

Dependent Variable: REGR factor score 7 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	-.347	.151	-2.301	.023	-.644	-.049
[Gender=1]	.520	.142	3.654	.000	.239	.801
[Gender=2]	0[a]	.	.	.	.	.
[AreaStudy=1]	.157	.170	.927	.355	-.177	.492
[AreaStudy=2]	.086	.188	.454	.650	-.286	.457
[AreaStudy=3]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Estimates

Dependent Variable: REGR Component Score 7

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
male	.261	.101	.062	.460
female	-.253	.099	-.449	-.057

Pairwise Comparisons

Dependent Variable: REGR Component Score 7

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
male	female	.514*	.142	.000	.234	.793
female	male	-.514*	.142	.000	-.793	-.234

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

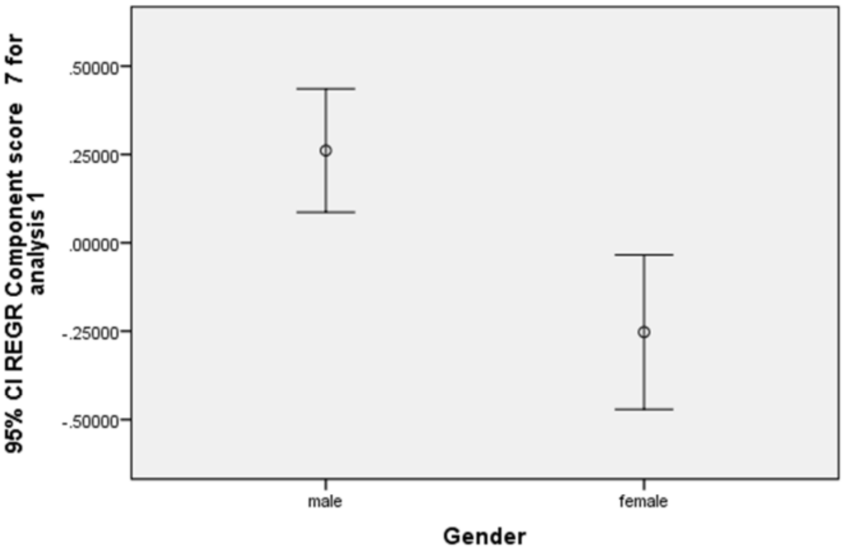


Table A4.15 Analysis of Score of Component 8

Tests of Between-Subjects Effects

Dependent Variable: REGR Component Score 8

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.334[a]	4	1.584	1.604	.175
Intercept	.001	1	.001	.001	.978
Gender	4.643	1	4.643	4.704	.031
ReducedEthn	1.791	3	.597	.605	.613
Error	179.666	182	.987		
Total	186.000	187			
Corrected Total	186.000	186			

a. R Squared = .034 (Adjusted R Squared = .013)

Parameter Estimates

Dependent Variable: REGR factor score 8 for analysis 1

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	-.021	.157	-.133	.894	-.331	.290
[Gender=1]	.318	.146	2.169	.031	.029	.606
[Gender=2]	0[a]	.	.	.	.	.
[ReducedEthn=1.00]	-.161	.186	-.864	.389	-.527	.206
[ReducedEthn=2.00]	-.115	.239	-.480	.632	-.586	.357
[ReducedEthn=3.00]	-.268	.202	-1.322	.188	-.667	.132
[ReducedEthn=4.00]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Estimates

Dependent Variable: REGR Component Score 8

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
male	.158	.103	-.045	.362
female	-.153	.102	-.354	.047

Pairwise Comparisons

Dependent Variable: REGR Component Score 8

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
male	female	.312*	.145	.033	.026	.598
female	male	-.312*	.145	.033	-.598	-.026

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

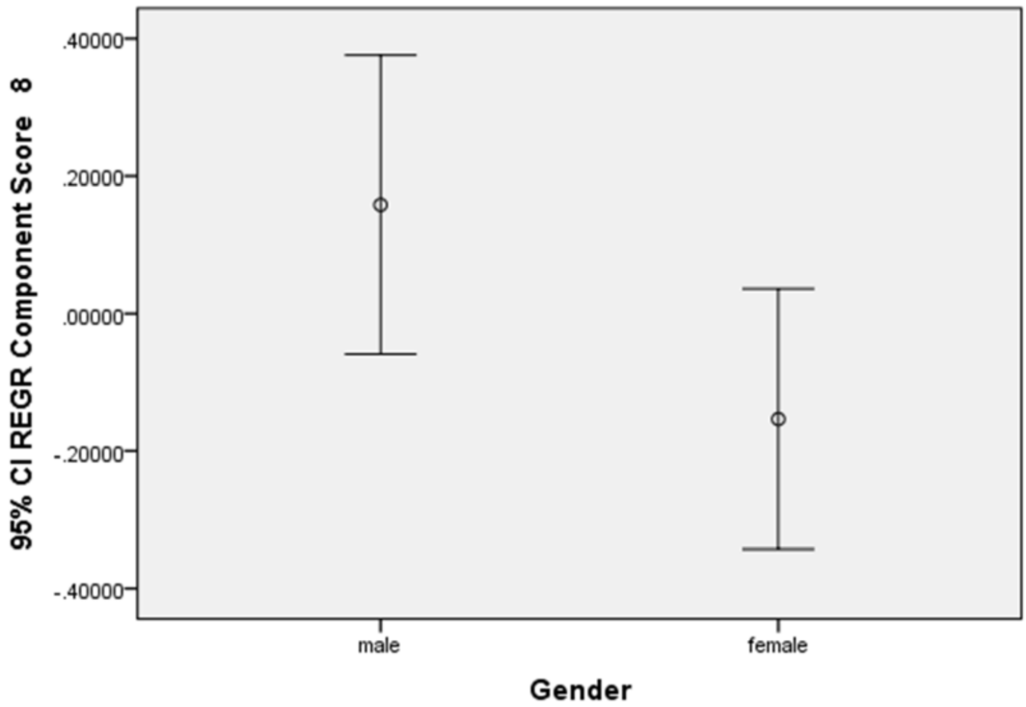


Table A4.16 Logistic Regression of *'18. Worked examples with exercises to solve help stimulate my mathematics learning'* **on Age and Gender**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	78	.000
	mature	122	1.000
Gender	male	92	.000
	female	108	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.756	.644	1.378	1	.240	2.130	.603	7.524
	nAge(1)	.265	.626	.179	1	.672	1.304	.382	4.448
	Constant	2.345	.520	20.345	1	.000	10.438		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.17 Logistic Regression of *'17. A short lecture followed by a tutorial session help stimulate my mathematics learning'* **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	67	1.000
	mature	106	.000
Gender	male	78	.000
	female	95	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.881	.534	2.729	1	.099	2.414	.848	6.871
	nAge(1)	.441	.561	.617	1	.432	1.554	.517	4.666
	Constant	1.659	.367	20.436	1	.000	5.254		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.18 Logistic Regression of *'16. Being in a class of students with similar ability help stimulate my mathematics learning'* **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	71	1.000
	mature	102	.000
Gender	male	79	1.000
	female	94	.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.121	.418	.083	1	.773	1.128	.497	2.558
	nAge(1)	.261	.430	.368	1	.544	1.298	.559	3.012
	Constant	1.490	.312	22.838	1	.000	4.435		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.19 Logistic Regression of *'19. A lecture that works at my pace help stimulate my mathematics learning'* **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	70	1.000
	mature	104	.000
Gender	male	80	.000
	female	94	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.626	.555	1.273	1	.259	1.871	.630	5.553
	nAge(1)	1.073	.667	2.590	1	.108	2.926	.792	10.813
	Constant	1.737	.386	20.229	1	.000	5.681		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.20 Logistic Regression of *'20. The teaching techniques employed help stimulate my mathematics learning'* **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	71	1.000
	mature	100	.000
Gender	male	83	.000
	female	88	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.810	.727	1.239	1	.266	2.247	.540	9.350
	nAge(1)	.971	.820	1.402	1	.236	2.640	.529	13.168
	Constant	2.235	.469	22.717	1	.000	9.350		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.21 Logistic Regression of '27. Seeking assistance at an early age is effective strategy for learning mathematics' on Gender and Age

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	68	1.000
	mature	117	.000
Gender	male	87	.000
	female	98	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	2.097	.784	7.157	1	.007	8.144	1.752	37.861
	nAge(1)	1.424	.791	3.239	1	.072	4.155	.881	19.595
	Constant	1.452	.343	17.897	1	.000	4.273		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.22 Logistic Regression of *'26. Attending classes regularly is effective strategy for learning mathematics'* **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	70	1.000
	mature	104	.000
Gender	male	80	.000
	female	94	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.626	.555	1.273	1	.259	1.871	.630	5.553
	nAge(1)	1.073	.667	2.590	1	.108	2.926	.792	10.813
	Constant	1.737	.386	20.229	1	.000	5.681		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.23 Logistic Regression of *'15. Having extra assistance (such as a tutor) available help stimulate my mathematics learning'* **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	63	1.000
	mature	99	.000
Gender	male	76	1.000
	female	86	.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.104	.534	.038	1	.846	1.109	.390	3.156
	nAge(1)	.704	.602	1.365	1	.243	2.021	.621	6.583
	Constant	1.936	.383	25.616	1	.000	6.931		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.24 Logistic Regression of *'1. The perception that mathematics is a difficult subject'* **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	66	1.000
	mature	111	.000
Gender	male	87	1.000
	female	90	.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.576	.306	3.534	1	.060	1.778	.976	3.241
	nAge(1)	.383	.316	1.473	1	.225	1.467	.790	2.724
	Constant	-.600	.251	5.741	1	.017	.549		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.25 Logistic Regression of ' *2.Mathematics is a subject in which male students are more likely to be successful*' **on Gender and Course**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Business biomed maths	Business	83	.000
	Biomed+Maths	94	1.000
Gender	male	87	1.000
	female	90	.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.555	.308	3.237	1	.072	1.742	.952	3.189
	CiyBioMaths(1)	.634	.310	4.194	1	.041	1.886	1.028	3.461
	Constant	-.788	.277	8.096	1	.004	.455		

a. Variable(s) entered on step 1: Gender, CiyBioMaths.

Table A4.26 Logistic Regression of *'2. Mathematics is a subject in which male students are more likely to be successful'* **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	56	.000
	mature	92	1.000
Gender	male	59	1.000
	female	89	.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	1.173	.424	7.673	1	.006	3.232	1.409	7.413
	nAge(1)	1.167	.501	5.433	1	.020	3.214	1.204	8.576
	Constant	-2.668	.503	28.125	1	.000	.069		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.27 Logistic Regression of '*32. The learner's gender affects the successful learning of mathematics*' **on Gender and Age**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	67	.000
	mature	102	1.000
Gender	male	75	1.000
	female	94	.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.397	.543	.535	1	.464	1.488	.513	4.312
	nAge(1)	.302	.573	.278	1	.598	1.353	.440	4.156
	Constant	-2.712	.548	24.511	1	.000	.066		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.28 Logistic Regression of '*4. It is likely that some ethnic groups are better at mathematics than others*' on Gender and Ethnicity

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
White and non-white	White	58	.000
	Non-white	104	1.000
Gender	male	71	1.000
	female	91	.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.292	.330	.787	1	.375	1.340	.702	2.556
	nWhite(1)	.896	.355	6.362	1	.012	2.450	1.221	4.916
	Constant	-1.075	.321	11.189	1	.001	.341		

a. Variable(s) entered on step 1: Gender, nWhite.

Table A4.29 Logistic Regression of *'4. It is likely that some ethnic groups are better at mathematics than others'* **on Age and Ethnicity**

Categorical Variables Codings

		Frequency	Parameter coding (1)
White and non_white	White	58	.000
	Non-white	104	1.000
Grouped as matured	20 and under	60	.000
	mature	102	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	nAge(1)	.196	.340	.331	1	.565	1.216	.625	2.367
	nWhite(1)	.926	.354	6.855	1	.009	2.524	1.262	5.047
	Constant	-1.088	.366	8.843	1	.003	.337		

a. Variable(s) entered on step 1: nAge, nWhite.

Table A4.30 Logistic Regression of *'10. Studying mathematics will make me more employable and help in my career'* **on Age and Gender**

Categorical Variables Codings

		Frequency	Parameter coding (1)
Grouped as matured	20 and under	68	1.000
	mature	100	.000
Gender	male	78	.000
	female	90	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	1.449	.679	4.556	1	.033	4.258	1.126	16.102
	nAge(1)	.454	.632	.516	1	.473	1.574	.456	5.428
	Constant	1.755	.395	19.757	1	.000	5.781		

a. Variable(s) entered on step 1: Gender, nAge.

Table A4.31 Logistic Regression of *'14. The importance given to mathematics in society is over-stated'* **on Age and Gender**

Categorical Variables Codings

		Frequency	Parameter coding
			(1)
Grouped as matured	20 and under	47	1.000
	mature	74	.000
Gender	male	57	.000
	female	64	1.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Gender(1)	.333	.379	.772	1	.380	1.395	.664	2.932
	nAge(1)	.793	.383	4.281	1	.039	2.210	1.043	4.683
	Constant	-.848	.321	7.005	1	.008	.428		

a. Variable(s) entered on step 1: Gender, nAge.