PUBLIC IMAGES OF MATHEMATICS

by

LIM CHAP SAM

Submitted to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Education, in April 1999; awarded July 1999.

Abstract

This study explores the range of images, beliefs and attitudes towards mathematics as reported by a sample of 548 adult members of the public of the United Kingdom. It also explores in greater depth the possible causal factors of influence on the formation of these images of mathematics for a smaller subsample. In this study, the term ‘image of mathematics’ is conceptualised as a mental representation or view of mathematics, presumably constructed as a result of social experiences, mediated through interactions at school, or the influence of parents, teachers, peers or mass media. This is also understood broadly to include all visual and verbal representations, metaphorical images and associations, beliefs, attitudes and feelings related to mathematics and mathematics learning experiences.

The design of this study was explorative and modestly interpretative. Both quantitative and qualitative methods were used to analyse the data collected from a questionnaire in stage one (N=548), and by semi-structured telephone interviews, in stage two (N=62).

From a synthesis of both quantitative and qualitative data, five common themes emerged as components of respondents' image of mathematics. These are (i) utilitarian, (ii) symbolic, (iii) absolutist, (iv) problem solving, and (v) enigmatic views.

There are differences in these images and beliefs about mathematics between those who claimed to like mathematics and those who claimed to dislike mathematics. Notably, the former group of respondents tends to view difficulty in mathematics as a challenge, and attributes success in mathematics to effort and perseverance. In contrast, the latter group tends to view difficulty in mathematics as an obstacle, and attributes failure to their own lack of inherited mathematical ability or blamed on others (particularly, their mathematics teachers). These differences were also observed between a subsample of UK teachers and students (n=231), and a sample of Malaysian teachers and students (n=407) in a cross-cultural comparison study, which was carried out as a sub-study of this study. The majority of the UK teacher and student sample tended to attribute

success in mathematics to having inherited mathematical ability whereas their Malaysian counterparts more commonly tended to attribute it to effort and perseverance.

In addition, the interview data suggest that the teaching styles and the motivation given by these respondents' mathematics teachers, and their parents [mostly father] were the two most important factors of influence on the formation of their attitudes to mathematics and images of mathematics.

Although limited in generalisability, these findings suggest that differences in (i) beliefs about attribution to success in mathematics, (ii) mathematics teachers' teaching styles, and (iii) motivation given by mathematics teachers and parents may lead to differences in images and beliefs of mathematics. These in turn may lead to the differences in attitudes towards mathematics and learning mathematics.

Contents

CHAPTER 4: METHODOLOGICAL ISSUES

CHAPTER 5: Findings of stage one

CHAPTER 6: Findings of stage two

List of Tables

Page

List of Figures

Acknowledgements

I am very grateful to many people who have given me their supports, without which I might not have succeeded in completing this study. In particular, I would like to thank the following people:

My sponsors -- both the Association of Commonwealth Universities (UK) and the University of Science Malaysia (Malaysia), for their financial supports.

All the British publics who found time to respond to my questionnaire and interviews, even though to most of them, I was just a stranger that they met on the high street.

All the Malaysian teachers and students who have responded to my questionnaire.

My supervisor, Professor Paul Ernest whom I am most grateful and indebted to. He has constantly encouraged and motivated me to do much better than I can. His insightful suggestions and critical comments have helped me to grow both academically and personally.

My second supervisor, Mrs Sue Jennings for her critical comments and suggestions.

Professor Mangho Ahuja for his incisive and constructive comments, as well as his encouragement and moral support through many e-mails.

My colleagues and friends from the University of Exeter for their support and encouragement at all times, in particular, Jamie Aylward for valuable computer and technical consultation, Lotte Hammer for validating my data, Rohaniah Mettusin for reading my final draft, and many others for their valuable moral support.

All my colleagues and friends from the University of Science Malaysia for their support and encouragement at all times.

Lee Siew Eng, for her patience and precious time in reading the first draft of this thesis and for her constructive comments and suggestions that have helped to improve the initial draft of my thesis.

My mother for her love and care and all brothers and sisters for their moral support.

My loving husband whose constant support and encouragement has strengthened me both morally and spiritually, from the very beginning to the completion of this study.

Chapter 1

Introduction

1.1.Focus of study

This study aims to make a systematic enquiry into the public's images of mathematics and the possible causal factors of influence on the formation of these images. In this study, the term *image* is defined as some kind of mental representation (not necessarily visual) of something, originated from past experience as well as associated beliefs, attitudes and conceptions. Since an image originates from past experience, it comprises both cognitive and affective dimensions. Cognitively, it relates to a person's knowledge, beliefs, and other cognitive representations. Affectively, it is associated with a person's attitudes, feelings and emotions. (In Chapter 3, I will explain why I classify 'belief' as cognitive rather than affective). Thus the term '*image of mathematics'* is conceptualised as a mental representation or view of mathematics, presumably constructed as a result of social experiences, mediated through school, parents, peers or mass media. This term is also understood broadly to include all visual, verbal representations, metaphorical images and associations, beliefs, attitudes and feelings related to mathematics and mathematics learning experiences. Therefore, the main aim of this study is to explore and identify the range of images, beliefs and attitudes towards mathematics as it is perceived by the public (mainly adults).

1.2. Public images of mathematics

It is widely claimed in the literature (see example, Henderson, 1981; Sewell, 1981; Mtetwa & Garofalo, 1989; Frank, 1990; Ernest, 1996) that, negative images and myths of mathematics (and mathematicians) are widespread among the public, especially in the developed countries. Henderson (1981) claims that "the majority of people today are scared of mathematics (and mathematicians) and feel powerless in the presence of mathematical ideas" (p.12). Many people's images of mathematics represent mathematics negatively, such that mathematics is perceived to be "difficult, cold, abstract, and in many cultures, largely masculine" (Ernest, 1996, p.802). Others describe mathematics as "fixed, immutable, external, intractable and uncreative" or "a timed-test" (Buxton, 1981, p.115). Even scientists and engineers whose jobs relate to mathematics "often harbour an image of mathematics as a well-stocked warehouse from which to select ready-to-use formulae, theorems, and results to advance their own theories" (Peterson, 1996).

In addition, there is a widespread conception that public attitudes towards mathematics are largely negative. There is some, albeit limited, evidence to support this. The Cockcroft Report (Department of Education and Science, 1982) reported Brigid Sewell's experience that half of the members of the public she stopped to interview on the street immediately declined and walked away when they learnt it was about mathematics, indicating a negative reaction (Sewell, 1981).

Sixteen years later, this similar trend is still evidenced in an international survey by the Basic Skills Agency (1997) on the numeracy skills of adults in seven countries, namely France, Netherlands, Sweden, Japan, Australia, Denmark and United Kingdom (UK). The UK sample ranks the highest in percentage of outright refusal to answer (13%), while in other countries, the percentage of outright refusal was at most 6%. Indirectly, these results suggest there is a lack of interest in mathematics or a relatively higher tendency of mathematics avoidance among many of the UK adults.

Furthermore, many adults of most Anglo-American countries are not embarrassed to proclaim their ignorance or poor performance in mathematics, unlike on other subjects. Educators attempt to explain this phenomenon through the widespread beliefs or mathematical myths that "learning mathematics is a question more of ability than effort" (McLeod, 1992, p.575) or "there is an inherent natural ability for mathematics" (FitzSimons et al., 1996, p. 768). Thus, many adults accept this lack of accomplishment in mathematics as a permanent state over which they have little control.

Apart from that, some students, in particular students with mathematics learning difficulties (Mtetwa & Garofalo, 1989) and some preservice teachers (Frank, 1990) were also found to hold some common mathematical myths. Some of these myths are 'mathematics is computation'; 'mathematics is difficult'; and 'men are better in mathematics than women'. Even though mathematical myths are not necessarily false beliefs, they are mostly negative and could be harmful in distorting the image of mathematics of the students.

Three widely claimed mathematical myths in the literature are:

(i) Mathematics is a difficult subject

It is claimed that to many people, mathematics is perceived as a difficult subject to learn and to teach. When Cockcroft (1994) expressing his personal views about the report, *Mathematics Counts* (Department of Education and Science, 1982), he stated that, "I believe we would be mistaken if we failed to recognize that however we design our programs, *mathematics is unlikely ever to be an easy subject to teach and to learn* (italic added)…"(p.37). However, it is also this notion of difficulty in mathematics that attracts some people to mathematics. Serge Lang (1984) in his famous public lecture on mathematics to a group of non-mathematicians expressed this in his personal view:

> I must also add that I do mathematics also because it is difficult, and it is a very beautiful challenge for the mind. I do mathematics to prove to myself that I am capable of meeting this challenge, and win it (p.5).

Therefore, the notion of mathematics as a difficult subject is taken by some persons as a challenge, whereby if they succeed in solving the mathematical problems, then there is a strong sense of satisfaction. It is also this sense of satisfaction and challenge that can motivate them to go into higher level mathematics. Conversely, if they failed in advanced study, then this sense of failure might result in low self-esteem.

(ii) Mathematics is only for the clever ones

Closely related to the preconception that mathematics is difficult, is the claim that mathematics is only for the clever ones, or only for those who have 'inherited mathematical ability'. Consequently, people who excel in school mathematics are highly respected and considered to be the intelligent few. This is a common perception in Eastern countries such as China (as reported by Zhang, Liu and Yu, 1990). They are also perceived to be an odd species in some western countries. For those who fail or perform poorly in school mathematics, it is often assumed that they did not have the so-called 'mathematical ability'.

(iii) Mathematics as a male domain

Linking the above two myths together, Issacson (1989) proposes that mathematics has been seen to be a 'hard' subject, not necessarily in the sense of intellectually difficult, but hard as opposed to soft or feminine. This leads us to another widespread mathematics myth that 'mathematics is a male dominant subject'. Mathematics and science have always been stereotyped as strongly 'male' or 'masculine'. Perhaps traditionally, most mathematics teachers in secondary school and a large majority of mathematicians were found to be men. Moreover, mathematics as a field of study is often linked to masculine jobs such as military and engineering. Thus many people including primary and secondary students, adults, parents and even teachers regard mathematics as a male domain (Shuard, 1982).

There is also widespread belief that boys are better in mathematics than girls (Burton, 1989). Various factors have been proposed to contribute to this stereotyped image. Jacobsen (as cited in Burton, 1989) refers this image to the differences in childbearing practices, peer group expectations and social attitudes as the contributing factors. Burton (1989) relates the gender difference in mathematics performance or preference to "bias experienced through patterns of socialization over the period from birth to the end of formal education" (p.182). Further review by Gutbezahl (1995) also suggests that some females' underachievement in mathematics might have related to the negative expectancies and attitudes of their parents, teachers and peers. As a result, these negative expectancies may lower their self-confidence in some people's mathematics and consequently their lower performances in mathematics. Their lower performances reinforce the parents' and teachers' negative expectancies and the vicious cycle perpetuates.

From these proposed contributing factors, it appears that students' images of mathematics may have been greatly influenced by the social and cultural views. In other words, I argue that public view of mathematics could possibly play an important role in shaping the image of mathematics of our future generation.

Public images of mathematicians

If the public image of mathematics is negative, then according to Howson and Kahane (1990), the image of mathematicians is even worse. They are regarded as "arrogant, elitist, middle class, eccentric, male social misfits. They lack social antennae, common sense, and a sense of humour" (p. 3). In addition, the director of the Public Understanding of Mathematics Forum, Gene Kloz (1996) claims that mathematics profession is the most misunderstood in all of academia. According to him, the public thinks that mathematicians contemplate ancient proofs and work as lonely recluses. Moreover, the most common public image of a mathematician has been furnished by a physicist (example, Einstein) rather than a mathematician.

Why is there such a lack of appreciation of mathematicians' work by the public? Brown and Porter (1997) propose that the mathematicians themselves be blamed. This is because "mathematician themselves failing to define and explain their subject in a global sense to their students, to the public and to the government and industry" (p.11).

In spite of these indicators of claimed poor public images of mathematics (and mathematicians), negative attitudes to mathematics and widespread mathematical myths, relatively few systematic studies have been undertaken on the general public's images of mathematics. Thus the widespread conception that public images of mathematics are largely negative needs to be investigated and tested empirically.

In addition, there are other important reasons for investigating image of mathematics. Most notably, there is the recent decline in recruitment into higher education courses in mathematics, science, technology and engineering noted in the UK and a number of other anglophone countries, where negative views of mathematics (and science) are often cited as contributory factors. In relation to this, I will discuss three problems and issues on mathematics education that negative public images of mathematics are claimed to be among the possible contributing factors.

Related issues and problems

Negative views about mathematics (and science) and mathematical myths have been claimed to be one of the contributing factors to some teething problems in mathematics education. These problems include:

a) A low performance in mathematics and adult numeracy

Since 1980's, a number of national surveys on adult numeracy (see example Sewell, 1981; ACACE, 1982; Adult Literacy and Basic Skills Unit, 1987; Basic Skill Agency, 1997) have reported a low performance of a significant sample of the UK adults. In the latest international survey report (Basic Skill Agency, 1997), the UK respondents were found to perform relatively low, with only 20% of them completing all tasks correctly and almost half of them (47%) answered 10-12 questions correctly. This is comparatively lower than its European counterparts (such as 76% of the Netherlands, 68% of Denmark and 65% of France and Sweden).

Similarly, in the Third International Study of Science and Mathematics (TIMSS), pupils in England were reported to have achieved lower mean scores in mathematics than half of the other 46 countries. This pattern of achievement was found in both the 9-year-olds (reported in Harris, et al., 1997) and 13-year-olds (reported in Keys, et al., 1996a) in England.

These reports raise concerns for both the government and the mathematics education community. Was the increased problem of low performance in mathematics the result of the proclaimed poor public image and attitudes to mathematics? Conversely, have poor performances in mathematics in international comparison studies damaged the public image of mathematics?

b) A low enrolment of mathematics and science students in Higher Education

Unlike the other subject areas, there is a steady decline in the number of students taking up Advanced-level (A-level) and higher level mathematics in universities. Porkess (1995) points out that the number of students who took up A-level mathematics in 1995 was similar to what it was 30 years ago. However, since 1965, there has been a substantial increase in number of students participating in post-16 and higher education. The number of students taking A-level mathematics has been rising since then and reaches its peak in early 1980s. However, since 1984, the rate of student taking A-level mathematics has been falling steadily by almost 41%.

On the other hand, there is little hard evidence to support the claim that poor public image of mathematics is possibly one of the many factors that leads to the problem of low take-up in mathematics and science in higher education institutions. Past literatures (Dick & Rallis, 1991; Lee, et al., 1996) have shown that when students choose a subject to specialise in at A-level or university, they are very much influenced by the perceived relevance and usefulness of the subject areas in their future careers and their self confidence in that subject. If students perceived mathematics as a difficult subject and they lack self-confidence in the subject, then they will avoid taking up this subject at higher level. Furthermore, Dick and Rallis (1991) found that the effect of socializers, including parents, teachers and peers in influencing both subject choice and career choices could be subtle but powerful. Thus, I wish to argue that if the public image of mathematics is bad, then we can expect that these socializers or significant others in the lives of students are likely to discourage the students from taking up mathematics, and possibly science, at higher level. Consequently this problem of low enrolment of mathematics students at higher level may be perpetuated.

c) Shortage of mathematics and science teachers in school

Closely linked to the problem of low take-up are the decreasing rate of recruitment and their increasing rate of withdrawal from courses of student teachers specialising in science and mathematics. It was reported in the Times Educational Supplement (September 12, 1997) that the figures for recruitment into initial teacher training in mathematics and science were 21% and 18% below target in 1995 and 1996 respectively. In addition, for those who accepted the offer for secondary mathematics and science courses, the withdrawal rates were 17 per cent and 19 per cent respectively in those two years as recorded by the Graduate Teacher Training Registry.

Taverner and Baumfield (Times Educational Supplement, September 12, 1997) studied the reasons underpinning the high rate of withdrawal. They found that the main reasons are financial and social factors such as low pay, lack of respect for teachers and poor discipline in school. However, there are also other factors such as perceived lack of support from the higher education institute, and lack of partnership between school and higher education institution. The image of mathematics as a male domain also seems to affect some of the participants. One female maths graduate comments that, "The school department was predominantly male and seemed to hold the opinion that female teachers shouldn't be teaching maths É [sic] these teachers were making my life unbearable" (p.3).

Besides the above factors, perhaps the availability of alternate careers for mathematics and science graduates, such as in computing, banking and financial services which is growing with great rewards, might be another contributing factor that deterred some people from taking up mathematics teaching as a profession.

The shortage problem of mathematics and science teachers was also reported in many countries such as the United States (Beal et al, 1985), Nigeria (Bajah, 1993), and the United Kingdoms. Various incentives and measures have been taken to attract more young people to mathematics and science teaching but in vain. Worse still, the shortage problem has been claimed to link to decline in passing rate of A-level mathematics. As claimed by the chairman of the Numeracy Task Force, Professor David Reynolds that, "many schools would support the view that the recruitment crisis in maths teaching has finally hit the exam results" (Times Educational Supplement, September 4, 1998).

I will argue that the shortage problem of mathematics and science teachers might also be linked to the unpopularity of mathematics in society. Why is there no such an acute problem of shortage in other subject areas? Why do teachers prefer to teach English or humanity subject but not science and mathematics? The negative images of mathematics as difficult and boring while the image of mathematicians as odd and anti-social may very well discourage people from mathematics and science related careers.

Possible indications of causes to poor public images of mathematics

Having discussed the related problems and issues, there are propositions and speculations about the causes leading to the claimed negative and unpopular images of mathematics. Sewell (1981) proposes that "teachers' attitudes, the formality of much mathematics teaching, the seeming lack of relevance of mathematics to everyday contexts, fear of the subject, literacy problems, gaps in schooling, and parental expectations" (p.72) are the few possible causes. Bell (1989) speculates that most people initially have the capacity to appreciate the beauty of mathematics as an art, but sadly this appreciation "often get suppressed by distasteful school experience" (p.70). Likewise, Ernest (1996) claims that experience of learning mathematics in school, especially the negative ones, are possibly the dominant sources leading to the public image of mathematics. In sum, these propositions seem to suggest that three of the possible factors that influence negative public image of mathematics are (i) parents, (ii) teachers and (iii) school experiences.

However, there are yet to have sufficient empirical data to support these propositions. Past literature indicate that parents have significant influence on their children's attitudes to mathematics (Cain-Caston, 1986), on their mathematics self-concepts (Parsons, Alder, and Kaczala, 1982; Dickens & Cornell, 1990), and consequently on their mathematics achievements. Yet rarely does study explore parents' image of mathematics and how they could possibly influence their children's image of mathematics.

Similarly, the important role of teachers in learning is unquestionable. There are increasing numbers of studies that suggest that teachers' image of mathematics could have influence on their teaching instructions (see Raymond, 1993 and review of Pajeres, 1992, Lerman, 1993), yet only limited study explore the possible influence of teachers' image of mathematics on students' image of mathematics (see example, Brown, 1992).

Indeed, information gathered with regard to these possible factors will definitely enhance a better understanding of the roles of parents and teachers in mathematics education. Subsequently, this information can be used to propose or design for potential involvement of these people in bettering the mathematics learning and teaching.

In addition to the three factors discussed above, I propose there is another possible factor, that is 'social and cultural factor'. Henderson (1981) argued that many people viewed and learned mathematics in a rigid and rote way that has hindered their creativity. This condition is further "systematically reinforced by our culture, which views mathematics as only accessible to a talented few. These views and attitudes, besides affecting individuals, have become part of what separates and holds down many oppressed groups, including women, working class and racial minorities" (p.12).

Many cross-cultural studies (Ryckman & Mizokawa, 1988; Huang & Waxman, 1997) have shown that cultural beliefs and values might have significant influence on students' image of mathematics. The most notable was the debate between beliefs about mathematical ability and effort-related attribution to one's mathematical achievement. It is conjectured that Eastern countries tended to value one's effort more than one's mathematical ability whereas Western countries attributed ability more than effort to a person's success in mathematics.

However, to my knowledge, there is virtually no empirical study, which has explored and compared the images of mathematics between countries, such as Malaysia and the UK. Thus, taking the advantage of my background, I propose to carry out a substudy on cross-cultural comparison on image of mathematics between Malaysians and British public adults. As the public level of literacy and numeracy of both countries are not comparable, a comparison will only be made between a sample of teachers and students from both countries.

1.3 Possible Impacts of public images of mathematics

Despite the above issues and problems that claimed to be negatively influenced by a poor public image of mathematics, mathematics is albeit, important in the modern world in a number of aspects. The following are some possible impacts that may occur due to the negative public images of mathematics.

(i) Utilitarian aspect/personal importance

Everyone needs mathematics as part of his or her basic tools and skills for effective functioning in everyday life. For example, simple arithmetic skills are needed for use at home, in the office or in the workshop. Negative attitudes to mathematics mean a disliking of mathematics and this in turn could lead to avoidance of using mathematics in daily life. Subsequently, this creates low self-esteem or less confidence in using mathematics in daily life. The less a person uses mathematics, the less confident and the more anxious he or she feels about using it. Thus a vicious circle where a negative image of mathematics leads to low self-confidence in mathematics and in turn avoidance of mathematics might perpetuate.

(ii) Economic aspect/ national importance

An adequate supply of mathematics graduates may be an important factor in the workforce and is needed for the scientific and economic development of the nation. A poor image of mathematics can lead to a low take-up and consequently a shortage in the supply of qualified mathematicians, mathematics teachers and mathematics graduates.

Another impact of the public image of mathematics is its crucial role in teenagers' future career decision, especially at the age 16-18. A negative image of mathematics among the teenagers or their parents may discourage them from choosing careers related to or requiring science or mathematics studies. In this technological era, all nations need to have more science and mathematics students. As advocated by Howson and Kahane (1990) "… a bad image of mathematics may result in an enormous national loss in the near future. Conversely a good or improved image may prove immensely beneficial to any nation in the world" (p.4)

(iii) Democratic aspect/ societal importance

In a democratic society, it is desirable that as many citizens as possible can participate in decision making. Mathematical reasoning is needed for critical citizenship, for understanding and for the making of sensible and informed decisions such as in voting and on environmental issues. Poor public image of mathematics could help contribute to keeping the majority of the society mathematically illiterate. This results in a society with some oppressed groups such as women, ethnic minorities and the working class, lacking the conceptual tools and skills to participate fully in our increasingly mathematised culture.

(iv) Cultural aspect/cultural importance

Mathematics forms a major part of our cultural achievement and cultural heritage. Everyone should be allowed and enabled to appreciate the beauty of mathematics and its applications. This should lead to greater involvement in mathematics (and possibly increased) public support of mathematical activity and mathematics education. Conversely, a negative public image of mathematics might deter the public's interest in mathematics and deficit their chances of appreciating the beauty and power of mathematics. As a result, it might also deter public support in mathematics education and research.

(v) Moral aspect/importance of values

The power of mathematics can be misused to give biased interpretations of data and representations of knowledge. For examples, information quoted in advertisements and in political campaigns can be misrepresented to the public for the benefit of the parties concerned. Thus, certain values such as rationality, accuracy and honesty should be inculcated via mathematics teaching so that the public is mathematically literate and is aware of the importance of mathematics in these areas of values.

In view of this significance, it is no surprise that these five aspects constitute the aims and goals of the mathematics curriculum in many of the countries in the world. I will argue that this is also one of the important reason to promote a positive image of mathematics among the public.

1.4. Public Images of mathematics and public understanding of mathematics

Unfortunately, our societies are still divided into 'two cultures'. The low take up of mathematical or science studies means majority of the society is still mathematically or scientifically illiterate and under-informed. In relation to this, increasing effort has been put into promoting a positive public image of science and the public understanding of science recently through various authorities (for example, Royal Society, 1985a, 1985b; The American Association for the Advancement of Science (AAAS), 1989). However, there is relatively lack of parallel effort given to promote a better public understanding of mathematics.

However, there are concerns shown by some parties about the need to change the public's attitudes to, images and beliefs of mathematics. One example is the National Research Council of United States of America's (1989) report on the future of mathematics education (Everybody Counts), which puts considerable emphasis on the need to change the public's beliefs and attitudes about mathematics. Most efforts (such as Advisory Council for Adult and Continuing Education (ACACE), 1982; Gal & Schuh, 1994; Grier, 1994) have focused on the development and promotion of adult numeracy only.

One encouraging sign was a valuable study and report published by the International Commission on Mathematics Instruction (ICMI), titled 'The popularization of mathematics' (Howson & Kahane, 1990). The four key features of the popularization of mathematics suggested are: sharing mathematics with a wider public; encouraging people to be more active mathematically, and bring mathematics into human culture and providing mathematics for all. In reviewing this report, Ernest (1996) suggested that there is another implicit feature, which need to be made explicit with the popularization of mathematics. This implicit message is 'to improve the popular image of mathematics and popular attitudes to it' (p. 786). This emphasises the importance of promoting a positive public attitude to mathematics and a popular public image of mathematics in our societies.

Another more recent effort was taken by a group of mathematicians from Swarthmore who started the Mathematics Forum on the Internet, entitled 'public understanding of mathematics' (Klotz, 1996). Their aims are to communicate with the public [especially young people] both the pleasure and stresses of being a mathematician as well as to improve the public understanding of mathematics.

Issues to be addressed

Yet, there are still a number of issues that need to be addressed here. Firstly, before further effort is given to promote the public understanding of mathematics, and to change the widespread mathematical myths and negative image of mathematics, we need to have a better understanding of the public image of mathematics. Unfortunately, reviews of related literature indicate that so far relatively little systematic research studies have been done on myths and image of mathematics. Most discussions of the topic are theoretically based studies rather than empirical studies. There is some limited research studies on the views of pupils (see example, Hoyles, 1982), student teachers (see example, Civil, 1990) and women (see example, Buerk, 1982). Although there is an increasing number of investigation into adult's beliefs and attitudes towards mathematics (for example, Burton, 1987; Crawford, Gordon, Nicholas & Prosser, 1993; FitzSimons, 1993;1994a; Galbraith & Chant, 1993; Wood & Smith, 1993; Benn,1994), these studies often take the form of case studies. Moreover, the subjects of the studies were generally consisted of participants of courses in further education in mathematics. They were mostly not people on the street, selected at random (except Sewell's study, 1981) Thus, this study seeks to find the range of images that are held by public adult members, both in and out of education sectors. It also aims to uncover some possible reasons underlying the myths and perceived image of mathematics.

Secondly, a great deal of energy and resources goes into the mandatory schooling of all in mathematics from the age of 5 to 16. Currently there is a national concern with numeracy levels attained in international comparisons. This study is concerned with what is probably one of the two main outcomes of this investment (the other being the adult numeracy) among the post school population: namely the images, perceptions, beliefs, attitudes and appreciation of the public.

Lastly, past studies on cross-culture have focused on the debate between ability and effort leading to success in mathematics. However, the question of image as a whole has not been explored and compared. Therefore there is a need to investigate and compare between countries on their images of mathematics.

1.5. Aims of the study

In considering the issues and problems discussed above, as well as the needs to promote a better understanding of the public image of mathematics, the objectives of this study are:

1. To explore and identify the range of images, beliefs and attitudes towards mathematics of a selected sample of public adults.
2. To explore adults' views about the possible causes and sources of their images of mathematics and their attitudes towards mathematics.
3. To investigate any correlation between the range of images of mathematics and social divisions in terms of gender, age and occupational groupings.
4. To investigate whether there are any cultural differences in the range of images of mathematics among the students and teachers of the UK and Malaysian sample.

1.6 Research questions for the study

More specifically, the five main research questions for this study are:

1. What is the range of images, attitudes towards and beliefs about mathematics held by a sample of public adults?
2. What are the possible reasons of liking and disliking mathematics of these adults?
3. What are the possible factors of influence that resulted in their existing images of, attitudes to and beliefs about mathematics?
4. Are there any differences between the range of images, attitudes and beliefs concerning mathematics among the different gender, age and occupational groupings?
5. Are there any cultural differences in the range of images of mathematics among the students and teachers of the UK and Malaysian sample?

1.7. Significance of the study

There are widespread claims about the negative public image of mathematics, but very little systematic enquiry into it. Therefore the result of this study will provide systematic and empirical data on public images and myths of mathematics.

Secondly, by examining the different images, attitudes, belief and myths of mathematics that public adults hold, there is a potential for such images, attitudes, beliefs to be challenged, promoted or discouraged. The information obtained will enhance better strategies and measures for promoting Public Understanding of Mathematics.

Thirdly, the result of this study might inform us what is the extent of the influences of parents and teachers in shaping students' images of mathematics. This information can be used to promote positive influence while attempting to avoid the negative influences of these sources. It will help to understand better the roles of parents and teachers in the shaping of children's images of mathematics.

Fourthly, the findings will reflect possible implication for mathematics education and mathematics teacher education. Knowing how ex-students perceive mathematics learning experiences in school and how this could have influenced their images of mathematics will help us to understand better how mathematics should be presented in the classroom. This knowledge may help to enhance better curriculum planning and teacher development programmes.

Lastly, the impact of cultural difference on image of mathematics revealed in the comparison might serve to support or challenge the notion that mathematics is universal, value-free or culture-free. The findings might help to illuminate our understanding on whether the difference in culture and value system could have led to the difference in images of mathematics, and consequently the difference in mathematics achievement.

Having described the current scenario of the public understanding of mathematics and the importance and significance of the public images of mathematics, I argued that there is an urgent need to carry out this study. Before I conceptualise the theoretical framework of the study (in Chapter 3), I shall first review critically some related studies in literature. This is where I shall turn to now.

Chapter 2

Literature Review

This chapter begins with a brief overview of the Public Understanding of Science (PUS) movement and compares it with that of the Public Understanding of Mathematics (PUM). This is followed by a review of empirical studies on public images of mathematics as well as of the literature related to attitudes to and belief about mathematics and learning of mathematics. I also review studies that investigated the possible factors of influence to images, attitudes and belief about mathematics and learning mathematics, including from both the social psychology and cultural perspectives. Finally, I conclude the chapter with a summary and critique of existing research.

2.1 Public understanding of science (PUS)

Definition of public understanding of science

Generally, there is not much argument about the meaning of the terms, *science* and *public* but there is about *understanding*. As defined by the Royal Society (1985a), *science* was "interpreted broadly to include mathematics, technology, engineering and medicine, and to comprise the systematic investigation of the natural world and the practical application of knowledge derived from such investigation" (p.7). Even though mathematics was included in the definition, it is limited to certain areas of mathematics, such as statistics and probability that are used in scientific works. *Public* is defined broadly to include all members of society, aged 18 and above, including people employed in skilled and semi-skilled occupations, people employed in the middle ranks of management and in professional occupations, and people responsible for major decision-making in our society, particularly those in industry and government.

On the other hand, *understanding* is defined by the Royal Society as including "comprehension of the nature of the scientific activity and enquiry, and not just knowledge of some of the facts" (p.7). Later, quoting the public reaction to the Chernobyl incident as an example, Millar and Wynne (1988) argued that the conventional view of *understanding* in terms of "public's level of knowledge of the content of science" (p.388) is not helpful enough for promoting a better science education. Instead, they suggested the term 'understanding of science' need to be extended to include also "the *processes* by which scientific knowledge is obtained and validated" (p.388). Similarly, Irwin (1996) also supported this view that PUS need to extend "towards a more critical discussion of 'science-in-the-making' and the role of scientific evidence within social life" (p.169). He argued that "…an insight into 'science-in-the-making' can be of greater value in cases such as BSE [in Britain] than a more 'factual' understanding of biological and physical processes" (p.172).

Likewise, in a study of young people's image of science, Driver and her colleagues (1996) argued that in an effort to improve public understanding of science, school science need to include developing "students' understanding of the scientific enterprise itself, of the aims and purposes of scientific work, and of the nature of the knowledge it produces"(p.1). In short, the term *understanding* need to include a broader perspective, covering both content and process of all scientific knowledge and scientific works, as well as the purpose and nature of the knowledge it produces.

Activities and movement of PUS

In spite of the debate over the definition of PUS, there has been an increased official, scientific and media concern about public attitudes, knowledge and understanding of science in the past two decades. Various research studies and intervention policy agenda in the public understanding of science have been set up based on two basic assumptions:

> 1. "better public understanding of science can be a major element in promoting national prosperity, in raising the quality of public and private decision-making and enriching the life of the individual" (Royal Society, 1985, p.9) and
>
> 2. "if only the public was properly informed and 'understood' science better, people would have a more positive view of what scientists say and do, and this would be reflected in wider popular support (and more generous public funding) " (Millar and Wynne (1988) p.389).

For example, in the United Kingdom, an early official document related to this issue was prepared, under the chairmanship of Dr. W. F. Bodmer of the Royal Society in 1985. It aims to investigate and recommend measures in which public understanding of science might be promoted. Consequently, there have been some extensive research surveys, such as the Science Indicator survey series carried out in the United States (National Science Board, 1980-85) and the 1988 British national survey on public understanding of science (Durant et al, 1989; Evans and Durant, 1995). These surveys were mostly focussed on public attitudes and interest in science and technology.

Besides the United States and United Kingdom, a number of countries such as China (Zhang & Zhang, 1993), Japan (NISTEP, 1994) and Czechoslavachia (Filacek & Krizova-Frydova, 1994) also followed the PUS movement. These countries carried out similar research surveys, hoping that a better understanding of the public attitudes and knowledge of science might help to promote a better social and economic growth for their countries.

In general, the results of these surveys show that the public interest in science is relatively higher than their level of understanding of science (see example in the 1988 British national surveys). Moreover, British "respondents who scored lower on the scientific understanding scale tend to express less interest in science, to possess fewer educational qualifications, to be working class rather than middle class, to be female rather than male, and to be older rather than younger" (Evans and Durant, 1995, p.59). Similarly, in a Chinese survey, Zhang and Zhang (1993) concluded, "most of the public have not yet acquired a basic level of scientific literacy" (p.37).

Consequently, some efforts and measures have been taken by the scientific community and governments. These are, for example:

(i) Two international journals dedicated specifically to the discussion of these issues have been launched. The first one was an international journal, 'Public Understanding of Science' launched in 1990. Recently another journal with similar focus on PUS, 'Science Communication' was also launched (reported in Durant, 1997).

(ii) A recent major ESRC research initiative, efforts by the Royal Society and British Association for the Advancement of Science was the setting up of Committee on the Public Understanding of Science [COPUS] and the funding of various projects and initiatives that lead to promote public understanding of science.

(iii) The International Journal of Science Education has called for contribution to a special issue for 1999: The public understanding of science: implications for education. (Editorial, 1997, 19(10), 1115-1116)

Studies on images of science and scientists

Besides the above mentioned activities, several studies (Petkova and Boyadjieva, 1994; Long and Steinke, 1996; Driver, et al., 1996) have also investigated the public images of science and scientists. However, most of these studies have confined their samples to mainly children and high school students. Petkova and Boyadjieva (1996) analysed 290 high school students' essays written on the topic 'my image of the scientist'. Their findings indicate that the core characteristics (listed by more than 50% of the subjects) of a scientist are: wise, noble, intelligent, disinterested, objective, open minded, hard working, honest, independent in judgement, devoted to science and selfless.

Long and Steinke (1996) analysed images of science and scientists in four children's educational programmes. They found that the images of science as truth, as fun, as part of everyday life and the image that science is for everyone, were evident while science as mysterious and magical were not. On the other hand, the images of scientists as omniscient and elite were quite prevalent but images of scientist as evil and violent were not. Other images of scientists are eccentric and antisocial.

Similarly, Driver and her colleagues (1996) explored young peoples' images of science by interviewing intensively 30 pairs of students from each of three age groups (9, 12 and 16 years old). They found that "students see science as addressing questions relating to physical and biological phenomenon but not social phenomena" (p.138). These students also "tend to see the purpose of science as providing solutions to technical problems rather than providing more powerful explanations" (p.138).

They also observed that the younger students' images of science reflected their experiences of school science while the older students' images were drawn on a wider experience including outside school experiences.

The findings of these three studies thus suggest that since early age, children have developed their own images of science and scientists. More often, these images reflected their experience of school science.

In summary, literature on PUS is relatively well documented. PUS movement has attracted a widespread concern from both government and scientific communities and at both international and national levels. Even though the extent whether these initiatives and activities has actually helped to promote public understanding of science is yet to be assessed, there are, however, constant interest and active involvement from various parties in promoting PUS.

2.2 Public understanding of mathematics (PUM)

Unlike PUS, literature on PUM is comparatively scarce. There is yet any international journal specially allocated for the discussion of PUM. The most recent development pertaining to this was an Internet website set up for PUM forum (Kloz, 1996). However, the forum has been limited to promote communication among the mathematics communities through discussion and sharing of resource materials. To what extent it has helped to promote public understanding of mathematics has not been evaluated.

Although there is a widespread concern and an increasing empirical research on the public understanding of science, in mathematics, this parallel concern has mainly been with public levels of numeracy. In fact, there are some differences between numeracy and mathematics. FitzSimons and colleagues (1996) note that the term 'numeracy' has been used to carry different meanings and its meaning varies according to the social and cultural background of its users. In general, the term 'numeracy' is used more often in the Anglo-American countries while the term 'mathematics' is used in the German-speaking countries. Generally, "being numerate means having developed certain basic mathematical skills applicable to various situations in everyday life" (FitzSimons et al., 1996, p.756). On the other hand, to be 'mathematically educated' encompass a broader perspective. It means to "have a sound mathematical knowledge", to have "acquire knowledge about concepts and methods typically utilised in mathematics - about their power, and about their limitations" (p.756) as well as to have a critical stance about mathematics as a whole. In sum, *numeracy* is regarded as only an important part of *mathematics* that is required by any individual to function relatively effectively in every day life situation.

Thus, Public Understanding of Mathematics not only needs to cover the development and promotion of public understanding of numeracy, but also include the global understanding of mathematical concepts, its nature and purpose of mathematical knowledge and appreciation of the power of application of mathematics. However, as reviewed below, most empirical studies related to PUM have been focused on promoting public levels of numeracy only.

Research on numeracy

Since 1980's, there are a number of national surveys on numeracy (see Sewell 1981, ACACE 1982, Adult Literacy and Basic Skills Unit, 1987 and the Basic Skill Agency 1997) conducted in the United Kingdom. Most of these studies reported low performance of a significant number of the UK adults in numeracy levels.

Sewell (1981) interviewed 107 public adults about their use of mathematics in daily life. She met with widespread refusal, even though she attempted to replace the word, 'mathematics' by 'arithmetic' or 'everyday use of numbers'. She found that the main reason for most people's refusal to be interviewed "was simply that the subject was mathematics" (p.10). Her findings also indicated that many of the people she interviewed showed avoidance of mathematics use and this was most significant "among the women who had specialised in art subjects. The more educated were affected to a much greater extent than the less educated" (p.72). The results of Sewell's study thus raises concern over the poor attitudes towards mathematics of some UK public adults.

At the same time, a national survey was also set out by the Advisory Council for Adult and Continuing Education (ACACE, 1982) to measure the extent to which adults possess the basic mathematical skills called for in everyday situations such as shopping, judging value for money etc. The sample consisted of 2890 people over 16 years of age from England, Wales and Scotland. The results of this survey showed that about 30% of the adult sample could not handle simple division, subtraction or read a simple graph. In addition, "almost half the adult population is apparently not able to read simple *timetable* and more than half seemingly do not comprehend the meaning of the *rate of inflation*" (p.18). In terms of gender and age grouping, the males and those aged 25 to 34 were shown to be better in everyday mathematical abilities than the females and those aged over 65.

In a more recent survey report published by the Basic Skill Agency (1997), the numeracy skills of adults in seven countries, namely France, Netherlands, Sweden, Japan, Australia, Denmark and United Kingdom were compared using a set of 12 numeracy tasks. These tasks include addition and subtraction of decimals, simple multiplication, percentage and fractions were given as part of face to face omnibus survey to a representative sample of adults aged 16-60. Among the seven countries, UK respondents shown comparatively poor performance, with only 20% of them completing all tasks correctly. Almost half (47%) of them answered 10-12 questions correctly but this is much lower than the European counterparts (such as 76% of the Netherlands, 68% of Denmark and 65% of France and Sweden). Moreover, the UK sample ranks the highest in percentage of outright refusal (13%), while in the other countries, the percentage of outright refusal rate was at most 6%. Indirectly, these results indicate further the lack of interest in mathematics among many of the UK adults.

Even though there have been many debates about the notion of numeracy that these reports are based on, it is concluded by Coben and Chanda (1997) that "the picture painted by these reports is undoubtedly bleak" (p.376). As a result, there has been much concern by both the government and the education sectors to improve the numeracy levels of UK adults. It is believed that to improve the numeracy level of adults, effort has to begin from the early years. In May 1997, the newly elected Labour government announced a national numeracy target that, "for 75% of 11 year olds, by 2002, to achieve the standards expected for their age in mathematics" (quoted in DfEE, 1998(a), p.4)

Subsequently, the Numeracy Task Force (NTF) was established by David Blunkett, the Secretary of State for Education and Employment and chaired by Professor D. Reynolds. Its main task was to develop a national strategy to raise standards of numeracy in order to reach the national numeracy target by the year 2002.

The Numeracy Task Force published their preliminary report called 'Numeracy Matters' in January 1998. They proposed a series of recommendations for a National Numeracy Strategy that they believed would improve the numeracy standards of primary mathematics. Two of these involve the assistance of the public:

- A high profile, educational emphasis in the UNESCO sponsored World Mathematical Year 2000, involving the media, business, parents, schools and other partners in creating a national climate in which mathematics is seen as relevant and enjoyable.
- Homework guidelines to help parents play an active and enjoyable role in helping their children to become numerate.

(DfEE, 1998a, p.3)

Similarly, a great emphasis is put on the support from home and the wider society at large in the final report of the numeracy task force. A whole chapter was devoted to this recommendation and a discussion of it. The NTF claim that parents are probably the most important influential factors of their children in developing numeracy skill. They also claim that it is important "to change the public attitudes towards numeracy to the better, so that teachers who are trying to raise standard feel they are swimming with the tide of public opinion" (DfEE, 1998b, p.75).

Besides the NTF, various national numeracy projects have been established in many parts of the country. One of them is the West Sussex Numeracy Project (Ahmed and Williams, 1997) which focuses on teacher development and aims to improve pupils' numeracy. Other similar numeracy projects listed in the Numeracy Task Force preliminary report (1998a) include the National Numeracy Project, the Barking and Dagenham Project, the Hamilton Maths Project, and the Mathematics Enhancement Programme Primary (MEPP).

In summary, while the concerns of the public understanding of science initiatives have included the public's knowledge, understanding, attitudes and beliefs about science, including the nature of science as a whole, mathematical initiative have had narrower goals. These have primarily been to improve levels of public numeracy, and more rarely, to improve public knowledge and understanding of mathematical facts, skills and concepts. Thus although the Public Understanding of Science has a wide conceptual base encompassing cognitive and affective factors, mathematical concerns have tended to focus on basic skills in mathematics.

Popularisation of mathematics

Closely linked to the promotion of PUM is the recent effort in promoting popularisation of mathematics. Even though there are distinctions between them as Ernest (1996) points out, "the public understanding of mathematics is concerned to discover and describe public knowledge and beliefs about mathematics, whereas the central concern of the popularisation of mathematics is to enhance public attitudes to and involvement with mathematics" (p.786). However, improving public attitude to mathematics will indirectly lead to improved public interest in mathematics and consequently better public understanding of mathematics.

Since the late 1980's, there have been an increasing number of initiatives taken to improve the popularity of mathematics. These initiatives include:

(a) special celebration and events, for example, the year 1988 was declared in Great Britain as 'Primary Mathematics Year' while the year 2000 as the International Year of Mathematics. There was also the annual event of Mathematics Awareness Week, put forth by the Mathematical Sciences Community in USA.

(b) exhibitions such as the Pop Maths Roadshow (Howson and Kahane 1990), and the 'Maths Fun Fair' organised by the York Area Mathematics Teaching Group in 1998;

(c) projects that encourage the involvement of parents in their children's mathematics education, such as 'IMPACT' in UK (Merttens & Vass, 1993) and 'FAMILY MATH' in USA (De la Cruz & Thompson, 1992)

(d) publications such as books of mathematical games and puzzles, popular books on mathematics and its history. For example, Simon Singh's (1997) "Fermat's last theorem" and Reuben Hersh's (1997) "What is mathematics, really?" These books were aimed to make mathematics more accessible to the public and to popularise mathematical knowledge and history.

The above list of activities thus shows the variety of measures taken to popularise mathematics among the public (For a more comprehensive list, see for example, Ernest, 1996) However, these initiatives presuppose that mathematics is unpopular among the public. Furthermore, relatively little evaluation have been undertaken on these initiatives to ascertain their effectiveness. In fact, virtually no systematic studies have been undertaken to ascertain how popular or unpopular mathematics is, or how such attitudes are distributed according to the gender, age and occupational groupings within the population. Therefore, there is a need to research into public attitude and public images of mathematics before further measures can be taken for popularisation of mathematics or public understanding of mathematics.

Nevertheless what have the literature informed us about the public images of mathematics? This is where I turn to now to review and discuss some empirical studies on public images of mathematics.

2.3 Studies on Public Images of mathematics

Reviews of published research literature in mathematics education show that many researchers use the term 'image' rather loosely, and interchangeable with many different terms such as views, conceptions and preference. Very few researchers attempt to define this term explicitly. Many researchers (for example Burton, 1989; Kelly and Olham, 1992; Mura, 1992; Wilson 1992; Branco and Oliveira, 1996) tend to use the term 'image of mathematics' to include attitudes towards mathematics, and beliefs about the nature of mathematics or learning of mathematics. For example, Kelly and Olham (1992) use the term image of mathematics among teachers to refer to their views of mathematics and mathematics education, including beliefs about and attitudes to mathematics that are being communicated by these teachers to their pupils. Similarly, Wilson (1992) studies prospective secondary teachers' image of mathematics by investigating their knowledge of functions, their more general views of mathematics and mathematics teaching. Likewise, Branco and Oliveira (1996) focus on "the experience with mathematics that was recorded and crystallized in the memory of students and high school teachers and is presented as images" (p.159). On the other hand, Burton (1989) did not define the term 'image of mathematics' explicitly at all in her study of some top junior pupils' image of mathematics. Nevertheless, implicitly she refers their images of mathematics to their feelings, attitudes to mathematics and beliefs about mathematics learning (for example, "image of mathematics as difficult" (p.183)).

One exception is found in Brown's (1995) study. In an attempt to investigate the influence of teachers on children's image of mathematics, Brown (1995) defined image of mathematics as, "the personal theory which an individual holds about mathematics at the present time which will include feelings, expectations, experiences and confidences" (p.2-146).

In view of the heterogeneity of the meaning of the term 'image of mathematics' and there was relatively limited number of research studies on it, I chose to adopt a loose and broader perspective, by reviewing all studies that are closely linked to it. In other words, I considered the following terms to be theoretical interpretations of the term 'image of mathematics':

(a) attitudes towards mathematics,

(b) beliefs about mathematics,

(c) mathematical myths

(d) conception or views of mathematics, and

(e) emotion and feelings towards mathematics.

In the following subsections, I shall review and discuss empirical studies pertaining to the above constructs. As it is impossible for me to make a comprehensive review of all research studies, I have focused my review to recent research studies that fulfil at least one of the following criteria. Firstly, that aimed explicitly to investigate images of mathematics, and secondly, whose findings reflected images of mathematics, even though they might use different theoretical constructs of the image of mathematics.

(a) Research on attitude towards mathematics

McLeod (1992) notes that, "in the literature it is difficult to separate research on attitudes from research on beliefs" (p.582). This is because many studies on attitudes also include belief about mathematics and belief about self. In this study, I have adopted McLeod's definition of taking attitudes to refer to "affective responses that involve positive or negative feelings of moderate intensity and reasonable stability" (p.581), such as liking/disliking, interesting or boring etc. However, because of the ambiguity in discussing and citing the research studies, overlapping of research on attitudes and beliefs are inevitable.

Since the nineteen seventies, extensive reviews of research on attitudes towards mathematics have been carried out (e.g., Aiken, 1970, 1976; Kulm, 1980; Leder, 1987; McLeod, 1992, 1994; Ma & Kishor, 1997). These reviews show that studies on attitudes have been focused mainly on students' attitudes towards mathematics as a school subject. Research on student attitudes towards mathematics has also been conducted within a number of large scale evaluation studies, for example, the national study on pupils' attitudes towards mathematics by Assessment of Performance Unit [APU] (1988, 1991) and international comparison studies such as FIMS (Husen, 1967), SIMS (Traver & Westbury, 1989) and TIMSS (Keys et al., 1996a, 1996b and Harris et al., 1997). These studies often show that there is a tendency for attitude scores (especially on enjoyment and confidence subscales) to decline as students move from elementary to secondary school levels. Some major results illustrated from the APU surveys in Britain (1988 and 1991) are:

(a) 75% of both age groups (11-year-olds and 15-year-olds) perceived mathematics as useful.

(b) About one third of pupils from both age groups rate mathematics as difficult to some degree. Among the 11-year-old, 25 % of them are not sure whether mathematics is difficult or not.

(c) Comments made by the 11-year-olds suggest that enjoyment is an important factor on their attitudes towards mathematics, but pupils of aged 15 mentioned enjoyment far less frequently.

(d) In comparison between genders, for both age groups, boys tended to display greater confidence than the girls in their mathematical abilities and performance. There is also a higher proportion of boys than girls who find mathematics interesting or enjoyable, and who appreciated the usefulness and value of mathematics.

Gender differences in attitudes towards mathematics

There is a large body of research on mathematics attitudes as related to gender differences (Fennema & Sherman, 1976, 1978; Eccles et al., 1993; Vanayan et al., 1997). The results of these studies consistently support the claim that there is gender difference in mathematics attitudes as early as Grade 3 (Vanayan et al., 1997). Even though no gender differences were observed on many of the attitudinal variables such as 'liking' and 'enjoyment' (Steinback and Gwizdala, 1995; Vanayan et al., 1997), more boys than girls reported that they are good at mathematics and boys are likely to believe that they are more competent than girls do. In the high school grades, more boys than girls tend to perceive mathematics as useful (Fennema & Sherman, 1978). In short, boys tend to exhibit more positive attitudes towards mathematics than girls do and this disparity tends to increase with age.

Attitudes towards mathematics and mathematics achievement

There has also been much research on mathematics attitudes investigating the relationship between attitudes and achievement (Quinn & Jadav, 1987; Minato & Kamada, 1996); and the possibly correlated factors that influence students' attitudes towards mathematics (Reynolds & Walberg, 1992). Both narrative literature reviews (Aiken, 1970, 1976; Neale, 1969, McLeod, 1992) and meta-analysis (Ma and Kishor, 1997) on attitudes studies indicate that there is no consistent findings supporting the relationship between attitudes towards mathematics and achievement in mathematics. This relationship was found to be statistically significant but not strong enough for educational practice (Aiken, 1970, 1976; Neale, 1969; Ma and Kishor, 1997). While others found them "interact with each other in a complex and unpredictable ways" (McLeod, 1992, p.582). Although most studies claim that positive attitudes to mathematics might lead to better mathematics achievement but this causal relationship is normally weak and not confirmed by research evidence. Therefore, Ma and Kishor

(1997) pointed out that most probably there is a potential mediating variable between these two factors such as motivation or mathematics participation in class.

In general, the possibly correlated factors claimed to have strong link with students' attitudes to mathematics are motivation (Reynolds & Walberg, 1992), parents' attitudes towards mathematics (Cain-Caston, 1986), home environment (Cai, Moyer and Wang, 1997), cultural factors (Huang and Waxman (1997), and teachers' instructional quality as perceived by students (Reynolds & Walberg, 1992). These findings, however, are still far from conclusive because not all studies produce consistent evidence.

Adults' attitudes towards mathematics

In addition to this extensive literature on pupils and student attitudes, there has been a more limited set of investigations into adults' attitudes. This has included teachers' attitudes towards mathematics, both on pre-service teachers' (e.g., Ernest, 1988) and in-service teachers' (e.g., Moreira, 1991). Ernest (1988) investigates 30 preservice primary teachers with regard to their attitudes towards mathematics and their manifested attitudes and practices in mathematics teaching. Ten of these student teachers specialised in science and mathematics while the other 20 study French, History or English. Student teachers' attitudes towards mathematics were measured by a questionnaire that consisting of statements concerning liking and enjoyment of mathematics, and confidence in mathematics. His findings reveal that half of the 30 student teachers showed positive attitudes towards mathematics and one quarter of them showed negative attitudes towards mathematics. In terms of subject grouping, 90% of the Mathematics & Science student teachers have positive attitudes to mathematics but only 30 % from the other student teachers. Indirectly, his result implies that those who have higher qualifications in mathematics (such as the Mathematics & Science student teachers) exhibit more positive attitudes to mathematics than their non-mathematics counterparts. Perhaps this is not a surprise because these are also the students who chose to continue their studies in this area.

There is also a large research literature concerning 'maths anxiety', especially among college students, e.g., Battista (1986), Betz (1978), Dew et al. (1983), Hendel (1980), Llabre and Suarez (1985), Morris (1981), Resnick et al. (1982), Richardson and

Woolfolk (1980), Rounds and Hendel (1980), Tobias (1980, 1987). However most of these studies reflect the fact that many college students in the USA need to study mathematics as a requirement for graduating even though it is not their chosen subject of study.

To date, there has been relatively little study of the public's attitudes towards mathematics, independent of involvement in education. Sewell (1981) investigated public understanding and attitudes towards mathematics, and Buxton (1981) investigated the negative attitudes of a small group of adult women in depth. Yet studying the public's attitudes towards mathematics independently of involvement in education is clearly important, for choosing or being required to study mathematics might very well be correlated with skewed attitudes, either positively or negatively biased.

(b) Research on beliefs about mathematics

While there is a large research literature on attitudes towards mathematics, research on beliefs of mathematics is only gaining attention more recently. In mathematics education, research on beliefs has become a major focus within two main areas of research, namely problem solving (see Schoenfeld, 1989) and gender difference in mathematics (see Fennema et al., 1990). More recently, there is an increasing number of studies relating teachers' belief and their mathematics teaching in class (see review of Pajeres, 1992; Raymond, 1993).

In general, studies on beliefs of mathematics tend to focus on students and teachers, and they can be grouped under the following four strands:

1. belief about the nature of mathematics
2. belief about learning mathematics
3. belief about teaching mathematics
4. belief about self, including self-efficacy and own mathematical ability

In the following subsection, I shall review and discuss only the first two strands. The third strand concerning beliefs about teaching mathematics is related to teacher influence. The fourth strand, belief about self is closely related to self-factor. Therefore, these last two strands will be discussed in the next section with regard to the possible factors of influence on image of mathematics.

Beliefs about the nature of mathematics and learning mathematics

Using both quantitative (such as survey questionnaires) and qualitative methods (such as observation and extensive interviews), Frank (1988) investigated 27 mathematically talented [as measured by a standard test] middle school students on their mathematical beliefs and how their belief might influence the way they solve problem. His findings can be summarised as follows:

> 1. Mathematics is computation and followed that 'doing mathematics means following rules and learning mathematics is mostly memorisation'.
>
> 2. Mathematics problems should be quickly solvable in just a few steps.
>
> 3. The goal of doing mathematics is to obtain the "right answers"
>
> 4. The role of mathematics students is to receive mathematical knowledge and to demonstrate that it has been received.
>
> 5. The role of the mathematics teacher is to transmit mathematical knowledge and to verify that students have received this knowledge. (p.33)

Likewise, Cesar (1995) asked 331 pupils from the 7^{th} level at Lisbon for their images of mathematics as well as their reason of liking or disliking it. She found that most of them viewed mathematics as computation and some of them described mathematics as useful for daily or future life. The main difference between those who like mathematics and those who dislike mathematics, however, was that the former found mathematics interesting while the latter perceived mathematics as complex and difficult.

There are also many major national and international evaluation studies such as National Assessment of Education Progress [NAEP] (Brown et al., 1988), SIMS (Traver & Westbury, 1989) and TIMSS (Keys et al., 1996a, 1996b and Harris et al., 1997) have included beliefs about mathematics as one of their variables. In general, these data suggest that students believed that mathematics is important, useful but difficult and mainly involve memorising rules.

(c) Research on mathematical myths

Closely related to studies on beliefs of mathematics are studies on mathematical myths. There is an increasing number of studies (see example, Mtetwa & Garofalo, 1989; Frank, 1990) investigating mathematical myths that are held by students and preservice teachers in particular. As defined by Frank (1990), 'mathematics myth' refers to "a belief about mathematics that is (potentially) harmful to the person holding that belief because belief in math myth can result in false impression about how mathematics is done" (p.10). Even though 'maths myths' are not necessary 'false belief', if manifested in everyday life, they represent images of mathematics that are held by these people.

Kogelman and Warren (1978) identified twelve myths that are commonly related to those mathematics anxious and mathematics avoidance students. They are:

1. Some people have a math mind and some don't.
2. Math requires logic, not intuition.
3. You must always know how you got the answer.
4. There is a best way to do a math problem.
5. Math requires a good memory.
6. Math is done by working intensely until the problem is solved.
7. Men are better in math than women.
8. It's always important to get the answer exactly right.
9. Mathematicians do problems quickly in their heads.
10. Math is not creative.
11. It is bad to count on your fingers.
12. There is a magic key to doing math.

When analysed further, the list of myths shows that many of these myths are related to beliefs about the nature of mathematics and learning mathematics. Myth (1) and (7) suggest that there are gender differences in mathematical ability, myth (2), (8), (9) and (10) seem to imply that mathematics is a logical, rigid and hierarchical subject. While myth (3), (4), (11) and (12) suggest more of a dualistic view that there is a fixed way of getting the right answer, myth (5) and (6) indicate that memory and effort are important in doing mathematics.

Perhaps this is best summarised by Paulos (1992) when he proposes that there are at least five "mathematics-moron myths" (p.335) that need to be exploded by mathematics educators and teachers because they are as important as other educational issues such as curriculum reform and the use of technological tools. According to him, these five myths are:

1. Mathematics is computation;
2. Mathematics is a rigidly hierarchical subject;
3. Mathematics and narrative are disparate activities;
4. Mathematics is only for the few; and
5. Mathematics is numbing. (p.335)

These myths are also evidenced in Mtetwa and Garofalo's (1989) study. They investigated beliefs about mathematics held by students with difficulties with mathematics. They identified five myths that were commonly held by these pupils, which include, computation problems must be solved by using a step-by-step algorithm, and mathematics problems have only one correct answer. Perhaps holding these myths might have further discouraged these students from liking mathematics and as a result, they face difficulties in mathematics.

Apart from students, some of these myths are found to be held by some preservice teachers. Frank (1990) used the 12 myths suggested by Kogelman and Warren (1978) as a survey questionnaire to 131 preservice elementary teachers enrolled in a mathematics class. He found that at least half of them agreed with the first three of the list: (1) "Some people have a math mind and some don't." -- 63%; (2) "Math requires logic, not intuition." -- 53% and (3) "You must always know how you got the answer" -- 50%. There is also 44% of them agreed that "Math requires a good memory". All the twelve statements were chosen by at least 10 of the teachers. Thus, his findings indicate that these myths are common among these preservice teachers. He also gives evidence, through student writing that these myths have resulted in mathematics anxiety and mathematics avoidance for some of his preservice teachers.

Adding to the list of myths, Civil (1990) interviewed four prospective elementary teachers to find out their views about mathematics, particularly in a problem-solving context. In spite of different level of mathematical ability, she found that all of them believed that the three characteristic of doing mathematics properly are: 'neatness- such as writing problems in terms of equation'; 'speed - trial and error was dismissed as too slow' and 'professionalism such that using algebraic approach that was taught at high school'. She also observed that these students "did not believe in their own ways of doing mathematics. They felt more confidence when they could solve the problem using some pre-established mathematical procedure (even if they might not quite understand)" (p.8).

In short, these studies show that there are at least two mathematical myths that are held commonly by students and preservice teachers: (a) mathematics is only for the clever few, and (b) there is always a right answer in mathematics. This raises two immediate questions. Firstly, if these myths are common among our young generation, are they common among the older generation too? If they are, then we have a general public that is taken in by mathematical myths. This is alarming and raises concern. Thus the second question is how can we explode these myths because they might distort further the positive image of mathematics to our future generations? Therefore a study on public image of mathematics is clearly important to include investigating mathematical myths that are held by the public.

(d) Research on conceptions or view about mathematics

Recently, there have been increased number of research studies on conceptions and views about mathematics but most of these studies seem to focus on mathematicians (see example, Mura, 1992; Grigutsch & Törner, 1998; Burton, 1997), mathematics teachers (Kelly and Oldham, 1992; Wilson, 1992) and adult learners (Burton, 1987). Many of these studies categorised their results using the psychological or philosophical theories described below:

(i) Perry scheme of dualistic versus relativist belief system (Copes, 1982)

The Perry scheme was first introduced by William Perry (1970) who traced the epistemological development of his graduate students at Harvard. From intensive interviews, he drew up nine 'positions' or stages of epistemological development. Two of these are 'dualism' and 'relativism', which have been widely applied to views of mathematics by mathematics researchers (Copes, 1982, Ernest, 1996). The Dualistic view of mathematics is characterised by "mathematics is a fixed and absolute set of truths and rules laid down by authority" (Ernest, 1996, p.807). According to this view, mathematics is either right or wrong, it is certain and exact and there is always an answer to a question. In contrast, the relativist view of mathematics is that mathematics is "a dynamic, problem-driven and continually expanding field of human creation and invention, in which patterns are generated and then distilled into knowledge" (Ernest, 1996, p.808). Therefore, people who hold a relativist view of mathematics view mathematics as a social construction. They believe that a mathematical problem could be solved in more than one way and there is more than one possible answer to a problem.

(ii) Absolutist versus fallibilist philosophy of mathematics (Ernest, 1991)

Drawing on philosophy of mathematics, Ernest (1991) distinguishes two dominant epistemological perspectives of mathematics, namely the absolutist and the fallibilist views of mathematical knowledge. The main feature of the absolutist view of mathematics is that mathematics consists of a set of absolute and unquestionable truths. Mathematical truth is certain and exact. Mathematical knowledge is objective, value-free and culture-free. In contrast, the fallibilist view of mathematics is of that "mathematical truth is fallible and corrigible, and can never be regarded as beyond revision and correction" (Ernest, 1991, p.18).

Using these theories as a backdrop, I shall describe and discuss below some research studies that examined the conception or view about mathematics. I have grouped them by the type of sample, thus they reflect the images of mathematics that are held by certain subgroups of the public.

Mathematicians' view of mathematics and their works

Mura (1992) investigated the views of university lecturers from department of mathematics, statistics and computer science in Canadian universities. She received 173 responses from 444 of them on an open-ended question, 'how would you define mathematics?" Her content analysis shows that the two themes with the highest frequency are typical of (i) formalism, with "an emphasis on abstraction, logic, rigour, notation and symbolism" and (ii) "mathematics as a model of the real world" (p.8). However, only a few mathematicians' images of mathematics can be classified as "instrumentalist" i.e. who views mathematics as a set of unrelated but utilitarian rules and facts (Ernest, 1989). Only less than seven of them indicated that mathematics is the study of pattern or problem solving. Nevertheless, she found no significant difference in responses between gender and the field of specialisation (such as pure and applied mathematics).

Similarly, Grigutsch and Törner (1998) studied the images of mathematics held by 119 university mathematics teachers of German speaking countries. Using a closed questionnaire, they conceptualised the images of mathematics of these mathematicians into five major dimensions: formalism, schema, process, application and Platonism. According to them, the formalism aspect of mathematics is characterised by "strictness on different levels", including strictness on "terminology and language with its exactly defined terms and precise expert language"; "logical strictness and precision, flawlessness and abstraction" and "strictness on the level of argumentation, explanation and proof" (p.14). The schema aspect of mathematics "focuses on schemata and algorithms in mathematics" and describes " mathematics as a "tool box" or a "formula package" (p.15). In the process aspect of mathematics, "mathematics is characterized as a process, as an activity of thinking about problems and achieving realizations"(p.16). While the application aspect of mathematics "expresses mathematics has a direct application relation or is of practical use" (p.17), the Platonism view of mathematics as being application-free, but secure and aesthetic 'divine game' " (p.24). Their findings showed that more than 60% of the sample viewed mathematics in its formalism aspect and more than 90% of them viewed mathematics as a process. While 50% of them related mathematics to its application aspect, almost all of them rejected the view of mathematics as a collection of rules of procedures (the schema aspect). Surprisingly, only 15% of them held a Platonist view of mathematics.

Using a different approach, Burton (1997) interviewed 70 mathematicians in United Kingdom universities for their life histories, focusing on their career experiences of doing mathematics and their feelings about the nature of knowing mathematics. She found some surprising results. Firstly, contrary to "the false stereotype of the (male) mathematician, locked away in an attic room, scribbling on his white board and, possibly, solving Fermat's Theorem" (p.8) and working individually, she found most mathematicians that she interviewed preferred to research in collaboration or in co-operation with each other. Secondly, there was "a rich sense of pleasure" (p.10) among her respondents when they achieve success after many struggles. Thirdly, she found that almost all her respondents recognised the importance of having connection between their research with other mathematics or other real world data.

Even though the results of these studies might not be able to generalise to all mathematicians, they do provide us a snapshot of how a small group of mathematicians perceived mathematics and their own works.

Mathematics teachers and student teachers' views of mathematics

In 1992, Kelly and Oldham carried out a study on images of mathematics and mathematics education among primary teachers and students teachers. The results of their study show that these teachers' and student teachers' images of mathematics was largely 'absolutist and utilitarian' and their images of mathematics education was 'more process-oriented'. However, both sample groups seemed to find it difficult to differentiate their view of mathematics from their views on mathematics education.

Although the main aim of Wilson's (1992) study was to investigate the nature of teachers' specific understanding of functions, he also looked into their general views of mathematics and mathematics teaching of three prospective secondary mathematics teachers. He found that they communicated primarily dualistic views of mathematics and mathematics teaching. He also observed that one of the teachers viewed functions as computational activities because she believed that mathematics is a collection of specific procedures used to obtain the right answers. In contrast, another teacher viewed functions in a more flexible and dynamic way while the third one had a rich understanding of functions but a narrow view of mathematics teaching.

Knudtzon (1996, 1997) observed a similar dualistic view of mathematics exhibited by 28 of his student teachers. He found that they viewed mathematics as 'a subject with answers which are either right or wrong' while 'mathematics teaching consists of a teacher who explains how to do different tasks and pupils who follow the given procedures, doing lots of exercises' (p.287).

These three studies reviewed so far suggest that the most common conception of mathematics held by mathematics teachers and student teachers is a dualistic view of mathematics as having right or wrong answer.

Adult learners' view of mathematics

Burton (1987) developed courses for her students on an Access to higher education course. She observed that the images of mathematics of these students were characterised by 'closed and correct' and 'ritualistic and arbitrary'. Moreover, they seemed to have "considerable experience of their own inability to understand" (p.307). However, their images of mathematics changed after attending the Access course, to be much more positive.

In another study on adult learners, Allen and Shiu (1997) analysed the responses of 40 undergraduate students and 25 tutors of an open university course on an open-ended question: 'learning mathematics is like…'. Their preliminary analysis on these responses led them to four categories. Thus, in their sample, learning mathematics is taken as a "struggle leading to success", as "using learned skills", learning "patterns" or something that is "the unknown" (p.9).

These two exploratory studies on adult learners' image of mathematics show that most adult learners brought with them images of mathematics that have resulted from their previous experiences of learning mathematics in school. Moreover, these images are possible to be changed if they were exposed to different approaches of learning mathematics.

(e) Other image-related research

Other than studies on attitudes towards, beliefs of and conception about mathematics, there were a number of studies, which aimed to examine image of mathematics, but their results revealed more of emotions and feelings towards mathematics. Broadly speaking, these studies are related to the earlier section, (a) studies on attitudes towards mathematics. However, to highlight their findings that reflected images of mathematics in the forms of emotions and feelings, I have discussed these studies under this heading. These studies involved mostly women and pupils.

Women's view of mathematics

Buerk (1982) studies five "able" women who avoid mathematics and she found that these women experienced mathematics in a dualistic mode and "they see it [mathematics] as a discipline that is rigid, removed, aloof and without human ties, rather than one that is being discovered and developed" (p.20).

Likewise, in Sewell's (1981) study on the public adults' use of mathematics in everyday life, she also noticed a common feature to some of her women sample that, the more educated women tend to exhibit the least confidence in their mathematical ability. Regardless of their educational background, they tend to avoid mathematics by rationalising it as a male dominated subject. They showed reluctance to estimate because they believe that "only a completely correct answer were acceptable, even when an approximate answer has been asked for" (p.67).

In 1998, Colwell investigated the perceptions of 11 women on their use of mathematics in everyday lives. She observed that, "many of the stories reveal an avoidance of calculation or of using formal mathematical skills" (p. 57) and also many participants in her study 'talked a lot about their feelings about themselves and about mathematics, as well as about other people" (p.56).

The above three studies seem to suggest that women who disliked mathematics tend to avoid using mathematics in their everyday life. Even where they are highly educated and competent in their careers, most of them seem to hold a dualistic view of mathematics such that there is always a right answer or a right method to do mathematics. Presumably as a consequence of this belief, they are often not confident about their own mathematical abilities. Even when they obtained the 'right' answer with their own methods, they tended to distrust it and opted for some 'mathematical algorithm'.

Pupils' views of mathematics

By asking 14 year-old pupils to describe their good and bad experience of learning in school, Hoyles (1982) found that,

> Nearly one third of all good stories (42 out of the 135 stories) and one-half of all bad stories (72 out of the 146 stories) were, in fact, about mathematics learning. Out of the total of 114 mathematics stories, a significant proportion (over 63%) was bad.
>
> (p.358)

These results suggest that mathematics tend to provoke both strong and adverse reactions in 14-year-old pupils because over 63% of the mathematics stories told were bad. On further analysis on the possible reasons associated with these good or bad experience, she noticed that there are some marked difference in emphasis between the mathematics stories and stories about other areas. The main difference being the stress on 'self factor' in both good and bad stories of mathematics experience. Pupils were very concerned about their own roles in mathematics learning in addition to whether they could cope with the work they were doing. Similarly, there was a significantly larger proportion of the bad stories of mathematics learning expressing negative feelings about self in mathematics than in any other areas. In summary, these stories also "showed that anxiety, feelings of inadequacy and feeling of shame were quite common features of bad experience in learning mathematics" (p.368).

The above study on children's image of mathematics suggests that dating back to an early age, some pupils have perceived mathematics as difficult and complex. Some of them are experiencing negative feelings such as anxiety and frustration and these are probably associated to their bad learning mathematics experiences in schools.

In summary, review of studies on images of mathematics show that in general, many mathematicians, mathematics teachers and student teachers tended to hold a dualistic or absolutist view of mathematics while children and women tended to associate mathematics with negative feelings. Mathematical myths are held commonly by young students especially those who have difficulty in mathematics. However, these studies are mostly exploratory and thus their findings are still far from conclusive.

Moreover, many of these studies have focused on participants involved in some forms of education such as mathematicians (Mura, 1992; Burton, 1997), primary teachers and student teachers (Kelly and Oldham, 1992; Knudtzon, 1997); pupils (Hoyles, 1982), mature women students (Buerk 1982, Colwell, 1998) or adult learners (Allen and Shiu, 1997). Therefore, a more systematic enquiry into the public image of mathematics needs to cover a wider sample, including those presently involved in education as well as the general public who are not directly involved in education.

2.4 Possible factors of influence of image of mathematics and learning mathematics

As reviewed in the last section, there is large research literature on attitudes towards mathematics, and an increasing number of research studies on beliefs of mathematics and conceptions or views about mathematics. However, relatively few studies have been carried out to investigate the causal factors linking these theoretical constructs. Perhaps, there is no simple explanation in view that images, beliefs and attitudes are all personal constructs. They are probably not only influenced by a person's own experiences, but also likely to be influenced by his/her environment. There are various socio-psychological theories attempt to explain them, but so far there has yet to be one consistent theory that can explain it all.

Review of related literature shows that in general, these factors can be grouped under two main categories. Firstly, the learner-related factors such as self-interest, self-motivation and beliefs about the self that include self-confidence and causal-attribution. Secondly, the environment-related factors including parental influence, teacher influence, school experience, societal and cultural influence.

A. Learner-related factors

In any process of learning, a learner himself/herself is certain to play an important role. Whether one is interested in, motivated to, confident enough to learn something very much depends on how one views his/her own ability, self-image and self-motivation, besides other external factors. This in turn will inevitably affect how one responds to learning the subject. Therefore, in learning mathematics we would have expected the learner himself/herself to have some influence on his/her own attitude towards mathematics and their image of mathematics.

So far, most research on learner-related factors in learning such as self-esteem, self-concept, self-image or self-motivation has been better researched in psychology rather than educational studies. In recent decades, research on metacognition has gained its popularity in mathematics education, especially in problem solving. Yet in the affective aspect of mathematics education, beliefs about the self was the most researched factor.

Belief about the self

Past literature show that most studies on beliefs about the self tended to focus on students' self-confidence in doing mathematics, in particular the gender-related differences in mathematics. Many of these studies tended to use psycho-cognitive theory to link 'the self' and how one attributes success or failure in learning mathematics. The development of the latter has resulted in a number of attribution theories. Here I discussed three of these theories that have been commonly applied in mathematics education research.

(i) Learner-helplessness and mastery-orientation

According to Diener and Dweck (1978), children or learners could be classified broadly into helpless or mastery-oriented. When these children met with failures, the helpless children attributed their failure to lack of ability, in contrast, the mastery-oriented children made surprisingly few attributions but instead engaged in self-monitoring and self instruction. In other words, helpless children focused on the cause of failure while the mastery-oriented children focused on remedies for failure. These differences in attributions resulted in striking differences in strategy change under failure. The helpless student tended to attribute the cause to uncontrollable factors and spent very little time searching for ways to overcome failure. They tended to show low levels of persistence and to avoid challenges whenever possible. On the other hand, the mastery-oriented children tended to make adjustment to their strategies and responded to 'wrong' feedback as information leading to solution and not as a prediction for future failure. In brief, this theory explains the difference between these two types of learning behaviours of children in the nature of attribution following failure.

Based on causal attribution theory, including the concept of learned helplessness, Kloosterman (1984) has developed a model to explain student motivation and mathematics achievement in school. According to his model, student perceptions of success or failure in mathematics are followed by attributions, which then influence effort and finally achievement.

(ii) Expectancy x value theory

According to this theory, "for a student to learn something, the student must first feel that he or she has the possibility to achieve success (expectancy) and at the same time, must appreciate the rewards that come from succeeding (value). The relationship between expectancy of success and valuing the reward is not an additive but rather a product. If either factor is missing, the motivation of the student will be zero"(Grouws & Lembke, 1996, p.40).

(iii) Attribution theory of Achievement motivation and emotion

Weiner (1983) advocates that, "we feel the way we think"(p.165). Consequently, how one believes about reasons why certain thing has or has not happened (causal attribution) would influence one's feelings (emotion). Based on the results of two investigations into the relationship between causal ascription and feeling (Weiner, Russell, & Lerman, 1978, 1979), he proposed that the relationship between attribution and emotion can be summarised as in Table 2.1.

According to Weiner (1983), there were four dominant causal attributions (ability, long term effort, others and luck). Depending on an outcome of success or failure, these attributions give rise to some specific emotions. For example, 'the linkages for success are: ability - competence and confidence; long-term effort - relaxation; others - gratitude; and luck - surprise. For failure, the attribution-affect association are: ability - incompetence; effort - guilt and shame; others - anger; and luck - surprise' (p.169).

Table 2.1 Relationship between causal attributions and emotions

	Outcome	
Attribution	Success	Failure
Ability	Competence	Incompetence
Long-term effort	Relaxation	Guilt (Shame)
Others	Gratitude	Anger
Luck	Surprise	Surprise

(Adopted from Weiner, 1983, p.169)

In brief, Weiner's theory suggests that one's emotions or feelings towards something are partly responses to achievement-related outcome (success or failure) and partly attribute to causal factors (such as ability, long-term effort or others).

Self-attribution theory and gender differences

There is some research evidence supporting the hypothesis that boys show more confidence in mathematics than girls do. Vermeer, Boekaerts and Seegers (1997) studied 158 pupils of age 11-12 years old in Netherland on their perceived confidence and persistence in solving algorithmic and applied mathematical problems. Their findings showed that the boys perceived higher confidence than the girls in solving applied mathematics. However, the girls showed more persistence than boys in the same task.

This finding supported an earlier observation by Burton (1989) that even though the girls performed better at primary level, (such as invented better mathematical games) than the boys, they still showed less confidence than their counterparts. As one of the girls who according to her teacher was probably the most able child in the class, believed that,

> 'but everyone knows that boys get cleverer at maths as they get older, so it will get harder for us and easier for them' (p.181)

The results of these studies imply that there exist gender differences in perceived confidence in mathematics, whereby boys seem to have higher perceived confidence in mathematics than the girls do.

Further review by Gutbezahl (1995) shows that some females' underachievement in mathematics might have related to the negative expectancies and attitudes of their parents, teachers, and peers. These negative expectancies could have led to their negative self-expectancies and negative attitudes to mathematics and consequently led to their lower performances. The lower performances then reinforce the parents' and teachers' negative expectancies and a cycle of low expectancies leading to even lower performances is perpetuated. She further noted some possible reasons for this cycle to persist are:

> (1) Girls, more than boys, tend to believe that mathematical ability is something individuals either have or do not have;
>
> (2) Girls are more mathematics anxious than boys;
>
> (3) Girls may believe that "girls just cannot do math"; and
>
> (4) Girls' belief that their ability is so low that no amount of work will compensate, may drain their willingness to persist.
>
> (quoted from Abstract in ERIC documents)

These reasons indicate girls tended to exhibit much lower self-confidence but higher mathematics anxiety than their counterparts.

To conclude, these studies suggest that there are gender differences in attribution to success or failure in mathematics achievement, and in general boys exhibit higher confidence in their own mathematical abilities than girls do. Yet, very few studies attempt to relate one's own interest or self-image to one's image of mathematics. Thus, two questions remain:

(i) To what extent one's own interest, self-image or belief about the self influence one's image of mathematics?

(ii) To what extent one perceived that their liking or disliking of mathematics is due to their own interest?

A study on the possible factors of influence on image of mathematics will inevitably have to include these questions and this forms part of the aim of this study to investigate any relationship between image of mathematics and the 'self' factor.

B. Environment-related factors

Parental influence

There is a large research literature on parental influence and these studies mostly focus on the relationship between parents' attitudes towards mathematics (Cain-Caston, 1986; Parsons, Alder, & Kaczala, 1982; Pedersen Elmore, & Bleyer, 1986), parents' beliefs about their children's mathematical abilities (Wigfield, 1983; Yee et al., 1986), parents' expectation (Dickens and Cornell, 1990) and parental support (Yee, 1984, Reilly et al.,1992; Cai, Moyer and Wang, 1997) with their children's attitudes towards mathematics and/or their mathematics achievement.

Cain-Caston (1986) investigated the relationship between both parents' and students' attitudes towards mathematics and the students' level of mathematics achievement. Her study implies a direct influence of parental attitudes upon students' achievement. Her findings also indicate that there is a significant correlation between mother's attitudes towards mathematics and students' attitudes towards mathematics. However, a significant negative correlation was found between fathers' attitudes and students' attitudes towards mathematics.

Another two studies on parental attitudes (Parsons, Alder, & Kaczala, 1982; Pedersen, Elmore, & Bleyer, 1986), indicate that for both junior high and senior high school students, the parent's attitudes towards mathematics correlate to their child's mathematics achievement in terms of 'self-concept' factor and belief about the child as a mathematics learner.

Instead of parents' attitudes towards mathematics, Wigfield (1983) explores the influence of parents' beliefs on their children's belief in mathematics achievement. The children's beliefs in mathematics achievement were assessed in term of the children's self-concept of mathematical ability, perceived difficulty of mathematics, importance and values of mathematics, expectancies and intentions to take more mathematics. His sample consists of 740 children from fifth through twelfth grade and their parents. The results of his study showed that parents' beliefs about their children's mathematical abilities were related to the children's achievement beliefs.

Similarly, Yee and her colleagues (1986) carried three studies, involving parents and students of grades five to eleven, on the parents' belief with respect to their sons' and daughters' math competencies. Their findings indicated that (i) parents hold sex-differentiated beliefs about their sons' and daughters' mathematics ability even though boys and girls performed similarly on mathematics grades and standardised mathematics tests and (ii) parents strongly influenced children's mathematics attitudes and mathematics self-concept.

The important role of parental influence is also examined by Dickens and Cornell (1990), on the mathematics self-concept of 165 high-achieving adolescent girls. They found that parent expectations have a significant impact on adolescent girls' beliefs about their own mathematical ability. However, parents' mathematics self-concept has little direct effect on daughters' mathematics self-concept.

Looking at a slight different perspective, Yee (1984) investigates the relationship of family environment, in terms of parent-child relationship and parent motivation strategies, and the children's self consciousness in mathematics classroom. She administrated a modified version of family decision-making scale to 291 students in grades 4 to 8, and to 314 parents. Her findings showed that parents from highly conflicted or highly authoritarian family environments relied more on extrinsic motivation practices, while those from highly child self-regulating family environments relied more on intrinsic motivation practices. In addition, children from highly authoritarian family also reported greater self-consciousness in the mathematics classroom than their counterparts. These findings thus suggest that the type of family relationship could have impact on the children's motivation as well as their confidence in learning mathematics in school.

The importance of parental support and home environment in student's success in mathematics was shown by the study of Reilly and colleagues (1992). They surveyed 1152 students in vocational-technical and comprehensive schools in 13 New Jersey school districts, using an attitude scale and a mathematics test. They found that students whose mothers were not employed outside the home exhibited the lowest level of mathematics anxiety.

Similarly, Cai, Moyer and Wang (1997) investigated the relationship between the parental support and the children's mathematics achievement and attitudes towards mathematics. About 60% of the 220 middle school student's parents returned the Parental Involvement Questionnaire. The parental support was assessed in terms of five roles: (a) motivator; (b) resource provider; (c) monitor; (d) content adviser and (e) learning counsellor. Their findings show that students with the most supportive parents demonstrated higher mathematics achievement and more positive attitudes towards mathematics than those with less supportive parents.

The review so far thus give evidence that parents have significant influence on their children's attitudes towards mathematics and consequently their mathematics performance. However, most of these studies use correlational analysis, or standard attitudes scales such as parents' attitudes scale with students' attitudes scale and relating these scales to student achievement (usually measured by grades or performance in standard examination). Many studies focused on differences in parental expectation to boys and girls' ability in mathematics and related this to their success in mathematics. Yet rarely does study investigate parents' images of mathematics and how they could possible influence their children's images of mathematics.

In addition, the samples in these studies mostly consist of parents of primary, secondary or college students. Only a few studies that focusing on women sample attempted to link these women's attitudes to mathematics with their parents' expectations. Virtually no study investigates how the children think or perceived how much influence is their parental influence on how they view mathematics.

Therefore, the following questions remain:

- Do parents' images of mathematics influence their children's images of mathematics? If there is, to what extent is this influence?
- Previous studies show that parents' attitudes to mathematics correlate significantly to their children's attitudes to mathematics. But is this correlation only significant when the children are still in school only?
- The way the parent view mathematics is presumably to have an effect on the way they coach their children. If so, what will happen to the children when the parents' images of mathematics are different from the way mathematics is impinged in school?

But first and foremost, what are the images of mathematics of most parents? Parents are members of the public, thus the immediate question to investigate seem to be 'what is the public image of mathematics?'

School experience

Ernest (1996) suggests that many of the negative public images of mathematics are a result of their mathematics learning experience in school. He claims that "this is plausible because all members of the general public in modern industrialised societies spend many years as students of school mathematics" (p.810). Therefore, "experiences in school mathematics form the basis for the image of mathematics constructed by learners, especially negative ones. These in turn are a major source -- perhaps often the dominant source for the public's image of mathematics"(p.811).

Frank (1988) supports the claim that school experiences have important impact on pupils' problem solving. He argues that students' beliefs develop slowly through a long period of mathematics experience and encounters. For most students, mathematics classroom is probably the primary source of mathematics experiences. Therefore, what happens in the classroom will strongly influence the mathematics beliefs of the students in that classroom. These mathematical beliefs can either promote or hinder them as problem solvers.

Thompson's (1984) study suggests that school experience influences students' view of mathematics. She observed that one of her sample, Jeanne held two separate and unrelated views of mathematics that seemed to be the results of her experience of learning mathematics in school. "One was a positive view that seemed to have been influenced by a favourable experience with school mathematics. The other view was related to an unpleasant experience with college mathematics - specifically with calculus and linear algebra" (p.110). Jeanne could not understand what was explained by her mathematics teacher and since then, this experience appeared to have caused her to doubt her own mathematics ability. On the other hand, Kay, another mathematics teacher in Thompson's sample, was very confident about her knowledge of mathematics and her ability to teach. Apparently her confidence was a result of her successful experience in studying mathematics at school, and partly she attributed it to her inclination toward analytical thinking and logical reasoning.

In sum, school experience is thus widely claimed to influence people's beliefs and image of mathematics. However, more empirical evidences are needed to support this claim.

Teacher's influence

The significant role of teacher in learning is indisputable. As noted by the NCTM Curriculum and Evaluation Standard (1989) that,

> Teachers implicitly provide information and structure experience that form the basis of students' beliefs about mathematics. These beliefs exert a powerful influence students' evaluation of their own ability, on their willingness to engage in mathematical tasks, and on their ultimate mathematical disposition. (p.233)

Similarly in the Cockcroft report (Department of Education and Science, 1982), citing from the Royal Society (1976) stated that,

> …mathematics is especially vulnerable to weak teaching. 'there is no area of knowledge where a teacher has more influence over the attitudes as well as the understanding of his pupils, than he does in mathematics. During his professional life, a teacher of mathematics may influence for good or ill the attitudes to mathematics of several thousand young people, and decisively affect many of their career choices. It is therefore necessary that mathematics should not only be taught to all pupils, but well taught. All pupils should have the opportunity of studying in the accompany of enthusiastic and well qualified mathematics teachers'. (p.188)

Fennema and Peterson (1985) propose that teacher might act as an external influence on both students' internal motivational beliefs and on students' participation in classroom activities. Similarly, Clark and Peterson (1986) made an extensive review on research studies on teachers' thought processes, and they remark that these studies have provided some evidences that a teacher's thinking and other teaching behaviours are guided by and make sense in relation to the teacher's personal belief system. Therefore, I propose that a teacher's instructional decision, which are influenced by his/her beliefs, will influence how a learner do in the classroom and in turn may influence their learning as well as their images of mathematics too. In spite of there are evidences that a teacher's images of mathematics might influence his/her teaching instruction, but to what extent does teachers' image of mathematics influence their students' images of mathematics is relatively unexplored.

There is an increased concern about how teachers' images of mathematics might influence their students' (see Brown, 1992) images of mathematics. Several studies have taken into account how the values, belief and preference of teachers might influence the values and images of mathematics of their students (see Bishop, 1996; Lin & Chin, 1998; Leu, 1998).

Brown (1992) sets up to examine the influence of teachers on children's image of mathematics. She observed and interviewed four mathematics teachers and six of each of their pupils. She used a qualitative approach of 'story telling' and 'critical incidents' to probe for their images of mathematics. Her findings indicate that:

> Teacher A through challenging the pupils leaves with them an image of mathematics as initially hard but easy when it's sort out.
>
> Teacher B through using the structure of the SMP 11-16 individualised learning booklets leaves with the pupils an image of mathematics as a set of titles from their booklets.
>
> Teacher C sees mathematics as a framework of ideas which all link with each other and leaves with the pupils an image of mathematics based on using and applying it.
>
> Teacher D and the pupils have a common image of mathematics as enjoyable. (p.31)

Thus, her results implying that different teacher with different teaching approaches will result in different images of mathematics for their pupils.

Besides teachers' beliefs and teachers' image of mathematics, there are also some studies (Fennema et al., 1990) suggest that teacher's attributions about students' success or failure in mathematics could have influenced students' own attribution and consequently their achievement in mathematics. Fennema and colleagues (1990) attempt to determine whether teachers' beliefs and attribution differ between boys and girls' success or failure in mathematics. Thirty-eight first grade female teachers from 24 schools in United States were interviewed. They were asked to name two boys and two girls who were the most successful mathematics students in her class and then two boys and two girls who were the least successful in her mathematics class. She was then asked to choose the reasons for their success or failure. Seven attribution categories were given, namely student's ability, effort, intrinsic motivation, luck, easiness of the task, teacher helped and others helped (such as parents or peers). Their findings indicated that the teachers attributed differently about boys and girls' success and failure in mathematics. They perceived boys as being their best students and attributed 'ability' as reasons for successes and failure for boys but 'effort' for girls. Consequently, this difference in teacher's attributions for girls is widely believed to have a negative impact on achievement because girls might be led to perceive boys as having mathematical ability while they don't.

Another argument is that teacher's influence is more often implicit in a student's mathematics experience learning in school. Most students when asked to recall their mathematics learning in school often remember their mathematics teachers in relation to their personality or their methods of teaching. There is some research evidence on this.

Using a narrative inquiry, McSheffrey (1992) examines the underlying reasons that lead to women's avoidance of mathematics. He studies seven women and 15 eight-grade girls, using narrative-based tools such as letters, stories and interviews. His study shows that teachers were the focus of the stories told by most of the participants. These participants recounted their feelings in the mathematics classroom affected by their teachers and they ranked their teachers who can make connections to real life situations to be the best mathematics teachers.

However, more systematic studies are needed to explore further the influence of mathematics teachers and also to what extent have the public perceived their mathematics teachers to have influenced on their images of mathematics.

Social and cultural influence

There have been an increasing number of cross-cultural studies (Huang and Waxman, 1997; Ryckman and Mizokawa, 1988) investigating attitudes towards and beliefs about mathematics and their relationships with mathematics achievement. In a cross-cultural comparison study, Huang and Waxman (1997) surveyed 1200 Asian- and 1200 Anglo-American students' attitudes toward motivation, learning environment, and parent involvement in the learning of mathematics. Their results showed significant difference between motivation and perceptions of learning environment with the students' ethnicity, gender and grade-level. In brief, Asian American students demonstrated greater pride in their class work, a stronger desire to succeed, and higher expectations to do well in mathematics. They also enjoyed mathematics classes and assignments more than the Anglo-American students. Besides this, the Asian American parents were usually more interested and more involved in their children's work in mathematics learning than their counterparts.

In another cross-cultural study, Ryckman and Mizokawa (1988) cited similar findings. They survey 1106 White and Asian students in Seattle Public schools using the Survey of Achievement Responsibility questionnaire. Their findings showed that both groups attributed their academic success or failure to effort more than ability. However, the Asians tended to emphasise effort more than the Whites while the reverse was true for ability.

However, more recently, the oft-quoted claim that there is an Anglo-Saxon belief in ability while there is an Asian belief in effort has been challenged by findings of some studies (e.g Gipps & Tunstall, 1998; Elliot, Hufton, Hildreth & Illushin, 1999). Gipps and Tunstall (1998) asked 49 English young children (6 and 7 years old) to give reasons for success or failure related to some short 'stories' about classroom performance. Their findings show that effort was the most commonly cited reason, instead of competence in the specific subject areas. Similarly, in a cross-cultural comparison study between Sunderland (UK), Kentucky (USA) and St Petersburg (Russia), Elliot and colleagues (1999) asked children of aged 15 years from these three countries to rank in order of importance four reasons for succeeding in schoolwork. The four reasons include working hard (effort), luck, being clever (ability) and being liked by teacher. Interestingly, their findings display that effort was the major determinant of success chosen by the majority of the American and English children while ability was ranked as the most important determinant by the majority of Russian children.

Besides cultural values on effort and ability, the way mathematics is examined in entrance examination or public examination could possibly influences or distorts the image of mathematics held by pupils. One example was evidenced in the study of Lin and colleagues of Taiwan (1992). They found that ''EXAM Mathematics' gave rise to the students' view mathematics as 'computation, problem solving becomes problem routinization and learning mathematics is mostly memorizing'. Their further analysis, however, showed that teachers' belief and implicit social cultural factor behind this phenomenon might be more important than this 'EXAM Mathematics', which could be just a scapegoat only.

These studies have consistently displayed cultural differences in mathematics achievement as well as on attitudes towards mathematics. The differences in societal beliefs and cultural values have been cited as one of the possible explanations. The most popular one being Eastern society values effort, perseverance and hard work while western family tend to rely on mathematical ability and creativity as important contributing factors for success in mathematics. However, the latter claim has been challenged by more recent cross-cultural studies, albeit inconclusive.

2.5 Summary and critique

In summary, studies reviewed in this chapter suggest that there are a number of issues to be addressed.

Firstly, unlike Public Understanding of Science movement, the promotion of public understanding of mathematics is still in its infancy and most effort has been focused on numeracy rather than mathematics proper. Although there is an increasing number of initiatives in promoting popularisation of mathematics, popularity of mathematics among the public is still far from satisfactory. In fact, the effort to promote PUM and popularisation of mathematics indicate the presupposition that mathematics is unpopular in the public. This is also widely claimed in the literature. Yet, very few systematic studies have been carried out to explore or confirm the popularity of mathematics among the public members. In other words, the first issue to be addressed is " what is the public image of mathematics?"

Secondly, although the need to study images of mathematics has begun to receive increased attention from mathematics educators and researchers recently, most of these studies have been focused on attitudes and beliefs of mathematics. Moreover, there is yet to have a consensus definition for the image of mathematics. Therefore, a systematic enquiry into images of mathematics will first need to have a more coherent and systematic conceptualisation of the term 'image of mathematics'.

Thirdly, most research studies on images of mathematics have mainly sampled on students, teachers and those involved in some form of education sector. In general, findings from these studies show that the formalistic and dualistic views of mathematics are most common among the mathematicians and mathematics teachers. On the other hand, images of mathematics of the young students most likely reflected negative feelings and lack of confidence towards mathematics. The question remains: 'is this the general trend of images of mathematics among the public?' A systematic enquiry into public images of mathematics is clearly important to address to a wider sample, including not only those from the education sector but also those outside the education sector.

Fourthly, even though a number of mathematics educators (such as Ernest, 1996, Lerman, 1993) claim that school experiences and teachers are important factors influencing students' attitudes, beliefs and images of mathematics, relatively little empirical studies have been directed towards the issue of to what extent parents, teachers, peers and society's view of mathematics could have influenced people's images of mathematics. This issue might prove to be too complicated to be investigated. From another perspective, the question could be: 'to what extent do the learners themselves perceive that their images of mathematics could have been influenced by all these factors, other than themselves?'

Fifthly, mathematical myths seem to be common among the young generation as reviewed in the literature. Implicitly, mathematical myths reflect images of mathematics that are held by these students. Thus, a systematic enquiry into public images of mathematics will need to explore mathematical myths that are possibly held by the public, both young and old generations. Mathematical myths are difficult to eradicate because they might have been passed on from generations to generations. It is clearly important, however, to clarify the mathematical myths that are held by the public before any measure can be attempted to explode it. Another area that needs research will be to explore the mathematical myths that might have been held by adults.

Lastly, review of cross-cultural studies so far indicates that there are possible cultural influences on young students' attitudes to and beliefs of mathematics. In particular the attribution of success to ability verses effort, as well as the influence of home environment. However, these studies have tended to focus on young children and between Anglo-Saxon countries (e.g. UK and USA) and Far-eastern countries (e.g. Japan, Taiwan or Singapore). Therefore, more cross-cultural studies are needed to investigate any cultural difference in images of mathematics between adult students and teachers, and to include different countries (e.g. UK and Malaysia).

In considering these issues, I argue that there is an urgent need to explore the public images of mathematics. This review has helped me to conceptualise the framework of my study, which will be discussed in the next chapter.

Chapter 3

Conceptual Framework

In this chapter, I propose a conceptual framework for my study based on the rationale given in Chapter One and the literature review in Chapter Two. I begin by defining the terms: 'image', formation of image and image of mathematics. Next, I propose a conceptual analysis of the image of mathematics. Based on this analysis, I develop a conceptual framework for my study and present it in a diagram. Finally, I explain how this framework has helped me to design my methodology and the framework for analysis of my study.

3.1 Defining 'image of mathematics'

Before defining the term 'image of mathematics' as will be applied in this study, I reviewed the definition of its related terms, 'image' and 'image formation'.

What is an image?

The word 'image' carries many different meanings. It is defined in 14 ways by the Random House Webster's Unabridged Electronic Dictionary (1996). Besides its usual meaning of 'copy' or 'mirror image', it is used to include:

(i) 'a mental representation; idea; conception' or

(ii) (in *Psychology):* 'a mental representation of something previously perceived, in the absence of the original stimulus' or

(iii) (*Rhetoric.):* a figure of speech, esp. a metaphor or a simile.

(iv) the general or public perception of a company, public figure, etc., especially as achieved by careful calculation aimed at creating widespread goodwill.

More often, most artists and some psychologists (e.g.; Horowitz, 1983; LeDoux, 1998) tend to relate image to 'mental imagery', and choose to refer it to "mental contents that have a *visual* sensory quality" (Horowitz, 1983, p.3) or some kind of mental picture.

However, Thompson (1996a) argues that an 'image' is more than a mental picture. Instead, he characterised his meaning of 'image' broadly to include "experiential fragments from kinesthesis, proprioception, smell, touch, taste, vision, or hearing" (p.267) and also "fragments of past affective experiences, such as fearing, enjoying, or puzzling, and fragments of past cognitive experience such as judging, deciding, inferring, or imagining" (p.268). Thus Thompson's definition includes affective as well as sensory elements.

Rogers (1992) quoting from the Oxford English Dictionary defines image as a mental construct. He argues that:

> Throughout history, philosophers and mathematicians have been involved in the ontological questions about the status, 'reality' and existence of mental images. Whichever philosophical standpoint we take, we have to admit two fundamental aspects of this debate: first, we are aware of the power of the human mind to construct mental images; and secondly, our abilities to manipulate these images and use them to inspire creative thought, and many different forms of communication. (p.49)

This emphasises not only the cognitive aspect of images, but also their personal and idiosyncratic nature (their 'constructed' nature).

These definitions suggest that the notion of image as widely used is made up of at least two main components, (i) a cognitive component, including a mental picture, mental representation, an idea or conception, and (ii) an affective component, including attitudes, emotions, feelings, anxiety, enjoyment and fear. In addition, these definitions suggest that image is not necessarily a visual representation that what one sees, but "mental representation or mental experience of something that is not immediately present to the senses, often involving memory" (McLeod, 1987, p.497). As images can be retrieved or formed from memory, this suggests that images may be related to past experiences. Moreover, images can be represented not only in the form of visual representations (or pictures), but also in the form of verbal representations including, metaphors, similes or propositions.

How is an image formed or constructed?

Similar to the problem of finding a definition of 'image', I face similar conceptual difficulties in proposing an account of image formation. Researchers from different areas (such as neuro-biologists, psychologists and philosophers) tend to focus on different aspects of image and explain its formation differently. Horowitz (1983) points out that "while neurobiologists focus on anatomic and physiologic substrates as causes, psychologists focus on the cognitive use, psychodynamic meaning, and motivational aspect of image formation" (p.3). In contrast, philosophers have been argued about the ontological questions of 'reality' and existence of mental images (Rogers, 1992). In brief, most of these studies have been focused on the formation of 'visual representation' of image, and not the broad definition of image that I will propose in this study. Therefore, in keeping with the above definition of image, I propose a conjectural model of image formation as described below.

I suggest that we construct our image of something from what we have perceived or experienced. These experiences can be direct, or through primary sources such as from our own observations or experiences, or can be mediated through secondary sources such as what we have been told including what we hear or read about. As we perceive or experience more and more about something, our image of it is then developed, modified, expanded or gradually changed to a newly modified image. This process of image formation and modification continues as new images are constantly formed or modified from old experiences. However, if we stop experiencing something or perceive any stimulus that is related to it, then our image of it might remain unchanged in memory for a long time.

Definition of 'image of mathematics' in this study

As reviewed in Chapter 2, there is still a lack of consensus on the definition of 'image of mathematics'. This term has been used loosely and interchangeably with many other terms such as conceptions, views, attitudes and beliefs about mathematics. However, in this study, I choose to adopt both Thompson's (1996a) and Rogers' (1992) suggestions and define the term *image* as some kind of mental representation (not necessarily visual) of something, originated from past experience as well as associated beliefs, attitudes and conceptions. Since an image originates from past experience, it comprises both cognitive and affective dimensions. Cognitively, it relates to a person's beliefs, knowledge, and other cognitive representations. Affectively, it is associated with a person's attitudes, feelings and emotions. Thus the term '*image of mathematics'* is conceptualised as a mental representation or view of mathematics, presumably constructed as a result of social experiences, mediated through school, parents, peers or mass media. This term is also understood broadly to include all visual and verbal representations, metaphorical images and associations, beliefs, attitudes and feelings related to mathematics and mathematics learning experiences.

3.2 Conceptual components of images of mathematics

In relation to the above definition, the following constructs are suggested as conceptual components of the image of mathematics:

1. Images as attitudes and feelings

Attitudes, feelings and emotions comprise of many subcomponents, which are found to be significant in most of the images of mathematics claimed in the literature (e.g. Hoyles, 1982; Buerk, 1982; Colwell, 1998). Hoyles (1982) found that "anxiety, feelings of inadequacy and feelings of shame were quite common features" (p.368) related to the 14 year-old pupils' bad experience of mathematics learning. Likewise, Buerk (1982) found some 'able' women have their image of mathematics as "rigid, removed, aloof and without human ties" (p.20). Thus, a study of image of mathematics needs to include these components of attitudes and feelings about mathematics.

In mathematics education, extensive reviews on affective literature (example Aiken, 1970, McLeod, 1992, 1994) have shown that attitudes towards mathematics are usually defined as, "a learned predisposition or tendency on the part of an individual to respond positively or negative to some object, situation, concept, or another person" (Aiken, 1970, p.551).

In fact, the conceptualisation of attitudes to mathematics has developed from a single dimension to multiple dimensions. The more common attitudinal measures have been Aiken's (1974) two scales, Sandman's (1980) sixth scales, and Fennema and Sherman's (1976) nine scales. Other recent studies (such as Moreira, 1991) have either adopted or adapted some of these scales. In general, attitudinal measures have focused on these 10 scales:

1. Liking and enjoyment of mathematics
2. Motivation in mathematics
3. Confidence in learning mathematics
4. Anxiety towards mathematics
5. Perceived value of mathematics
6. The utility of mathematics
7. Learners' self-concepts in mathematics, including attributions of success and failure;
8. Perception of mathematics teachers
9. Mathematics as a male domain
10. Perception of the nature of mathematics.

For the purpose of this study, I will look at the first four scales, which focus on attitudes and feelings, as the affective components of the image of mathematics. These include liking, interested, confident; enjoyable, happy, bored, secure, nervous, threatened, certain or unsure; confused and worried as their subcomponents.

Of these ten scales, the last four refer to beliefs about mathematics (mathematics teaching), and hence they are regarded as the subcomponents of belief in the image of mathematics. As for the perceived value of mathematics and utility of mathematics (5, 6), these are attitudes proper but beyond the scope of this study.

2. Images and beliefs

Besides the affective domain, images are also mental representations that contain cognitive elements such as knowledge, beliefs, conceptions, metaphors and other related associations. In the literature, the term 'beliefs' is claimed to be situated between the cognitive and the affective domains (Pehkonen & Törner, 1996). There are so-called 'primitive beliefs', which are usually unconscious, and thus more inclined towards the affective component. On the other hand, there are 'conscious beliefs' which are considered to be cognitive, even though they may have an affective component. In the case of 'image of mathematics', there are possibly both cognitive and affective components of belief. However, for the purpose of this study, I have chosen to classify 'beliefs' as a cognitive component, as the beliefs considered here are largely relate to this domain.

From what we heard, read, observed or experienced, we form a belief about something. These beliefs could be related to our own self, the object of study or other people's beliefs. Therefore, the belief component of the image of mathematics might include belief about the self (such as self-confidence and beliefs about our own mathematical abilities), about the nature of mathematics, about the learning of mathematics as well as about the values in mathematics education.

3. Images as metaphors

Metaphors are pervasive in our daily life. We use metaphors to conceptualise, to represent and to communicate many of our thoughts and actions (Lakoff and Johnson, 1980). Indeed, our whole conceptual system of how we think and act may be fundamentally metaphorical in nature. According to Lakoff and Johnson (1980), a metaphor is a mental construction that helps us to structure our experience and to develop our imagination and reasoning. Moreover, according to Johnson (1987) metaphors are constructed through an 'embodied schema' or an 'image schema'. An embodied schema is defined as "structures of an activity by which we organize our experience in ways that we can comprehend. They are primary means by which we construct or constitute order and not mere passive receptacles into which experience is poured" (Johnson, 1987, pp.29-30). This means we construct metaphors to link our bodily experience of something to our more abstract thinking, and to "give shape, structure, and meaning to our imagination" (Sfard, 1994, p.47). Therefore, perhaps, it is not unusual for us to use metaphors to delineate our images or mental representations of something.

In fact, the use of metaphor in scientific thinking (e.g. Ortony, 1979, Martins & Ogborn, 1997) and as an analysis tool for mathematical thinking (Pimm, 1981, 1987) has been recognised for some time. Recently, there is an increasing number of study using metaphor to explore teachers' thinking (e.g. Cooney, et al., 1985; Munby, 1986;

Clandinin's, 1986; Bullough, 1991) and mathematicians' experience of understanding mathematics (Sfard, 1994). For example, Munby (1986) studied some teachers' use of metaphors in their descriptions of their work, and he concludes that "given the powerful link between metaphor and construction of reality" (p.206), the use of metaphors prove to be a promising alternative in exploring teachers' thinking. Thus, in this study, I propose to explore people's image of mathematics through the metaphors that may be given by my respondents.

In relation to image, Elbaz (1983) suggests that the notion of image as mental picture could take the form of 'brief, descriptive and sometimes metaphoric statement' (p.254). For example, Clandinin's (1986) study used metaphors such as 'classroom as home' and 'language as the key' to conceptualise teachers' personal practical knowledge and their classroom practice. In another study, metaphors such as 'teaching as parenting'; 'teacher as butterfly' and 'teacher as chameleon' are used to explore preservice teachers' personal teaching experience (see Bullough, 1991). Similarly, in this study, respondents will be encouraged to express their images of mathematics and mathematics learning in the form of metaphors, similes or some form of descriptions that exhibit their mental representations.

However, not everybody can express his/her image in the form of verbal representation such as metaphor or similes. Sometimes, an image of something might need to be implied or implicitly derived from episodic memories or critical incidents. Calderhead and Robson (1991) found that some student teachers' images of teaching were 'episodic memories, relating to particular significant events or people. Others were more general and have been abstracted from a variety of experiences' (p.4). This leads me to observe that there might be a close link between images and personal experiences. However, this link can only be explored through in-depth probing. Thus, following up an initial questionnaire, an in-depth interview would be held with a limited sample to explore any possible correlation between subjects' images of mathematics and their personal experiences.

4. Images and past experiences

From the definition of image, we notice the importance of past and present experiences in the formation of image. An image is not formed in a vacuum but is possibly affected by many factors of influence. To conceptualise the image of mathematics, we need to take into account the influence of past experiences related to the learning of mathematics. This includes experience concerning how mathematics is taught and learned in school, at home, and its use in daily life. In the process of learning and using mathematics, inevitably we received influences from the significant others such as parents, teachers and peers. Therefore questions asking the respondents to describe their past experiences of learning mathematics and their present use of mathematics in daily life will serve to probe into the possible factors of influence on their images of mathematics.

To sum up, an investigation into people's images of mathematics will need to include at least these four conceptual components of images of mathematics: attitudes and feelings about mathematics, beliefs about mathematics, image as metaphors, and past experiences of learning mathematics.

3.3 Conceptual framework

Based on the above conceptual analysis and review of past research, I have drawn out the conceptual framework of this study as represented in Figure 3.1.

Image of mathematics is taken to make up of three major components: attitudes, beliefs and metaphors. For each of these components, there are a number of subcomponents. Attitudes towards mathematics include liking, confidence, enjoyment, anxiety, feelings and perceived utility of mathematics. Beliefs about mathematics include beliefs about the nature of mathematics, the learning of mathematics, and about values in mathematics education. Image as metaphor includes all poetic, narrative or visual representations of image.

Besides these three components, images of mathematics are also conceptualised as closely related to past and present experiences of learning (and/or using) mathematics. These in turn are possibly influenced by many factors, both internal (such as own self-interest) and external (such as family, school, and society). Thus, I have used 'ellipses' to represent possible influences surrounded by these factors. The degree of influence might vary from one factor to another. The further in the ellipses the higher the conjectured degree of influence. In other words, family factors such as parents might exert more immediate influence than school factors, which include mathematics teachers and school policy. Similarly, the school factor is deemed to be more influential than the societal factor. Of course, this prioritising of influences is conjectural.

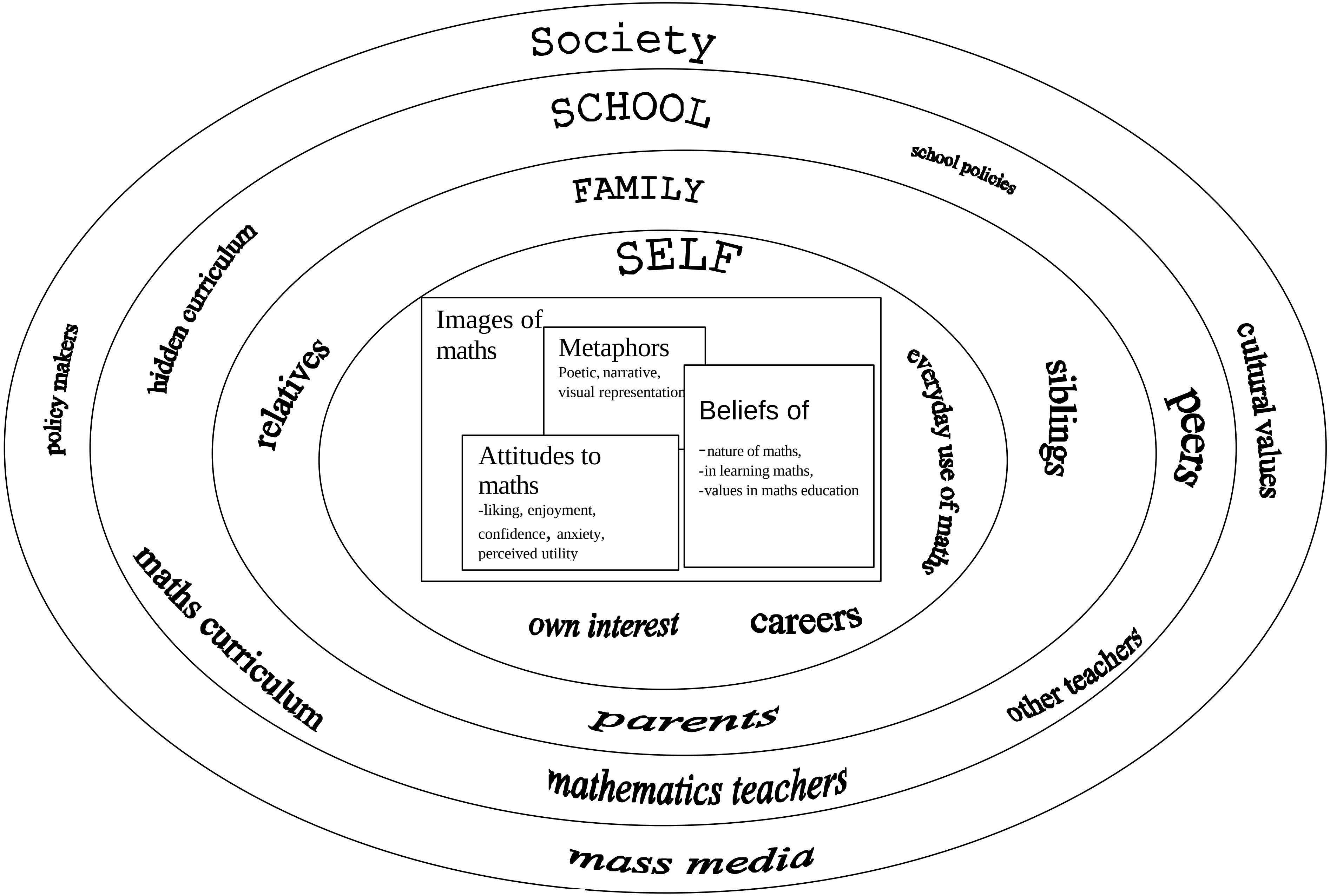


Figure 3.1: Conceptual framework of the study

As shown in Figure 3.1, the most immediate factor of influence on a person's image is his or her own self. This self-factor includes a person's own interest, self-motivation, everyday use of mathematics and the importance of mathematics related to their career needs. It also includes feelings, engendered in the self, which give rise to attitudes and beliefs. The next factor of influence is family and it is conjectured that parents might be more influential than any siblings and other relatives.

The third level of influence is school, where mathematics teachers might play major roles in their pupils' image of mathematics. However, other teachers, school policy and peers might also exert substantial influence on a person's image. Equally important but in a subtle way might be the mathematics curriculum and the hidden curriculum of the school. The last and also the largest ellipse is that of society. Societal influence includes mass media such as television, radio broadcast, newspaper and published materials. These, it is proposed, have an immediate influence on a person's image because of their accessibility and availability. But another important influence, albeit subtle, comes from cultural values and the policy makers.

In this model of concentric ellipses of influence, the outer regions influence the inner regions of factor. For example, school policies might be influenced by socio-cultural values. In turn, parents' image of mathematics could be influenced by their teachers' images of mathematics.

Before I draw out the design of this study, I attempt to operationalise the definition for two key words of this study, namely 'public and 'mathematics'.

3.4 Further Operational Definitions

Public

The report on public understanding of science (Royal Society, 1985a) uses the term 'public' to include the following five overlapping functional categories of science and mathematics users:

(i) private individuals for their personal satisfaction and wellbeing;

(ii) individual citizens for participation in civic responsibilities as members of a democratic society;

(iii) people employed in skilled and semi-skilled occupations, the large majority of which now have some scientific content;

(iv) people employed in the middle ranks of management and in professional and trades union associations; and

(v) people responsible for major decision-making in our society, particularly those in industry and government. (p.7)

For this study, I have adopted the criteria of the Royal Society to define the term 'public'. However, only category (i) to (iv) were referred in recruiting the sample of this study.

Mathematics

The term 'mathematics' can mean different things to different people. Does it include school mathematics, street mathematics, everyday mathematics, pure mathematics, applied mathematics or numeracy? FitzSimons and colleagues (1996) give a caution about assuming the heterogeneity in the meanings of the term 'mathematics', especially when it is related to adult learning. They argue that there is diversity within the field 'children and mathematics', especially when international comparisons are made, but when a single term is used to describe the subject, it is always 'mathematics'. However, "this is not the case with adults, where two main terms are used to described the subject: mathematics and numeracy; other variations include mathematical literacy and critical numeracy" (pp. 755-756).

I thus acknowledge the potential ambiguity and heterogeneity of the term 'mathematics' as it occurs in the first question of my questionnaire (Appendix A): 'Do you like maths?' Different people might interpret the term 'mathematics' differently or with respect to different levels of experience, study and mathematics qualification. I found that their notions of mathematics could vary greatly with the level of mathematics qualification of the people sampled. For those who have university degrees in mathematics, mathematics is viewed as a discipline of study, not only about number but also about higher level of mathematics including algebra, calculus, geometry, statistics and probability. For those with secondary or A-level in mathematics, mathematics is more than numeracy, and includes certain areas of pure and applied mathematics that they may have studied in school, such as algebra and mechanics. However, only very few of the sample finished schooling at primary or lower secondary level, such as at age 15. These groups tended to view mathematics as not more than numeracy, restricted mental arithmetic and everyday mathematics.

Therefore, when the sample were asked whether they like mathematics or not, their responses probably varied according to their interpretations of the term 'mathematics', and the difficulty in using a single term for this variety of meanings should be acknowledged.

In addition, for the purpose of this study, I used the term 'math' as an abbreviation for 'mathematics'. Thus in this study, the two terms are used interchangeably.

3.5 Design of the study

Based on the above conceptual framework, I have opted for an exploratory and interpretative approach as the design of this study. It is exploratory because the main aim of this study is to explore any general trend in images of mathematics among the adult members of the UK public. However, I acknowledge that 'image of mathematics' is a personal construct and there is no predetermined list of categories of image of mathematics for me to identify or confirm. Therefore I have to use various methods, including open-ended questions and interview, to explore this construct. It follows that the approach is interpretative because the responses or data gathered from these methods are textual and do not subscribe to any predetermined categories. I have opted to use grounded theory to analyse this part of the data. To analyse these data, I am aware of the possibility of researcher bias because I may interpret people's images of mathematics based on my own personal constructs. To minimise this bias, I will use triangulation of methods as well as cross-validating this part of the data with a panel of researchers.

On the other hand, I would argue that the study is interpretative only in a restricted sense because I also use some fixed-response questions to explore the sample's image, in particular, the other related constructs of image of mathematics such as attitudes to and beliefs about mathematics (mathematician).

As I aim to explore any general trend in the public images of mathematics, the sample has to be relatively large. As a result, it is impossible for me to analyse the data on an individual basis. I opted to use the quantitative methods such as frequency counts and ranking to display the analysis of my data. Therefore, on the whole, I consider the design of this study to be explorative and yet modestly interpretative, employing a combination of quantitative and qualitative methods in analysing and displaying my data.

As discussed earlier, I have conceptualised the 'image of mathematics' as consisting of four main constructs. The first two constructs: attitudes to mathematics and belief about mathematics are studied by using the quantitative method such as a fixed response questionnaire. Whereas the last two constructs, 'image as metaphors' and 'possible cause of image', are studied by using the qualitative method, including both open-ended questions and semi-structured interviews. The whole study is divided into two stages, the first stage is a short questionnaire given to a large sample size while the second stage is a follow-up telephone interview of a selected subsample. The detailed justification of methods chosen, and the development and administration of the questionnaire and the interview schedule will be provided in the following chapter.

Furthermore, to investigate whether there are any cultural differences in the range of images of mathematics across two countries, I have carried out a cross-cultural comparison between a subsample of UK teachers and students and a sample of Malaysian teachers and students, as a substudy. Full detail of this substudy will be reported and discussed in Chapter 8.

Chapter 4

Methodological Issues

In this chapter, I begin with a review of methods commonly used for research on image, attitudes and belief. I then argue that based on the conceptual framework that I have built up in chapter 3, I have opted for an explorative and interpretative approach, using both quantitative and qualitative techniques as the best way to achieve the aims of my study. Next, I justify my choice of the methods used and report on the development of the instruments in both stages of the research. In stage one, a short survey questionnaire is used while in stage two, a follow-up interview by telephone is administrated. Descriptions of the administration for each method are given in detail. I then justify my choice of sample and report on the actual sample used for both stages. Problems encountered during data collection for each stage are discussed and finally, I argue for the validity and reliability of the study.

4.1 Review of methods used in related studies of image

As discussed in chapter 3, I use the term 'images of mathematics' as a construct to include both cognitive domain (such as belief and knowledge) and affective domain (such as attitudes and feelings). Therefore, in search of the best methods or techniques for my study, I have reviewed all the methods I have found to be used in related studies of images, including studies on attitudes and beliefs, use of metaphors and methods of analysis. They are discussed briefly in the following section.

Review of method used in attitudes and belief studies

Extensive reviews of literature on attitudes studies (see Aiken, 1970, 1976; McLeod, 1992; Ma & Kishor, 1997) show that most research in this area generally "follow the traditional paradigm of quantitative research" (McLeod, 1992.p.588) such as the use of various types of questionnaires or some standardised attitudinal scales. For example, one of the most popular attitudinal scales has been the Fennema-Sherman Mathematics Attitude Scales developed by Fennema and Sherman (1976) to measure attitudes towards mathematics learning especially with regard to gender differences. On the other hand, previous research on beliefs have tended to use qualitative methods such as interviews and observations, except for large scale evaluation studies (for example, the Second International Mathematics Study, in Robitaille & Garden, 1989) where standardised beliefs inventories were normally used.

In recent years, more and more researchers have advocated the use of a wide variety of research techniques, including both quantitative and qualitative methods, for the best attainment of their research aims. McLeod (1992) proposes that "research on affective issues in mathematics education should develop a wide variety of methods" (p.591). Howe (1988) also points out that we are yet to find any convincing evidence that qualitative and quantitative methods are not compatible. Evans (1994) uses both qualitative and quantitative methods in his study on adults' mathematics anxiety and he too, suggests that we should make use of the strength of both methods as long as they provide the most effective ways to investigate our research questions.

A number of researchers (Schunk, 1991; Brookhart & Freeman, 1992; Munby, 1984, 1986) have recommended qualitative research methods as promising and appropriate for the study of beliefs. Shunk (1991) suggested that case studies and oral histories are best suited to gain deeper insight into an individual's beliefs system. Likewise, Munby (1984, 1986) suggested that a qualitative approach such as the use of metaphor is another potential method for the study of teachers' beliefs.

Similarly, after an extensive reviews of research on teachers' beliefs, Pajares (1992) proposes that besides the traditional method of using questionnaires and beliefs inventories, "additional measures such as open-ended interviews, responses to dilemmas and vignettes, and observation of behaviour must be included if richer and more accurate inferences are to be made" (p.327). In addition, he also suggests that, "current research in metaphor, biography, and narrative as ways to understand beliefs" (p.327) are some other promising research approaches.

In short, there is no 'the best' method for use in these types of research. The best method should be the one that can best help us to investigate what we need effectively. The choice of method also depends on the nature of the research design, namely the sample size and the research aims. For small sample size and in-depth studies, the qualitative method is more appropriate. For a large sample size and exploratory studies aiming for generalisation, quantitative methods using questionnaire might be more suitable, and more viable in terms of the cost and time involved.

Review of methods used in image studies

Compared to studies on attitudes and beliefs, there are relatively fewer studies on images. Even though the title of some studies involves the image of mathematics, they are often actually dealing with attitudes to and beliefs about mathematics. I have treated studies that have explicitly used the term 'image of mathematics' as part of their title or the aims of the study as image studies. I review the method and sample size used of 13 of these studies. They are summarised in Table 4.1.

As indicated in Table 4.1, most studies I found (8 out of 13) on images of mathematics have tended to use qualitative methods such as in-depth interviews or semi-structured interviews. Many of them also attempt to use other methods such as observations and other written instruments to collect data. Surprisingly, only 4 out of the 13 studies use questionnaires. Another interesting point is that almost all the questions asked about images of mathematics are in the form of open-ended questions. Perhaps this is not a surprise since image of mathematics is a personal construct. The usual close-structured questionnaire might not be suitable to explore this construct.

In terms of sample size, many of these studies employed relatively small samples. The samples ranged from as small as only three participants (e.g. Wilson, 1992) to 331 pupils (e.g. Cesar, 1995). There seems to be a correlation between sample size and the method used. Quantitative methods such as questionnaires are used for studies with sample size of more than 100 respondents while qualitative methods are used for those less than this size. This is understandable because the qualitative methods are usually more costly and time-consuming than the quantitative methods.

In summary, most studies on images of mathematics used quantitative methods when the sample size is large but qualitative methods if the sample size is small. Indeed, the more important criterion is the aim of the study. The quantitative method when used is mostly aimed to explore or identify a general pattern of images whereas the qualitative method is used for gaining better insight or understanding into persons' images and related areas.

Table 4.1: Summary of methods used and sample size of research studies on images of mathematics

Studies by name of author(s)	Questionnaire	interview	Other methods	Sample
Sewell, 1981		Interview and re-interviewing on daily life mathematical problems		107 public adults in the first interview and 50 for re-interviewing
Hoyles, 1982		Semi-structured Interviews		84 pupils of 14-year old
Buerk, 1982		Interview before and after session	Group discussion sessions on mathematical experiences; journal writing on reflection of five statements	Five intellectually able, mathematics avoidant women
Civil, 1990		Individual Interview (app. 2 hours)	Based on 4 mathematics word problems	4 mathematics student teachers (primary)
Mura, 1992	One open-ended question			173 mathematicians
Kelly and Oldham, 1992		In-depth interview	Class observation	4 primary teachers
Kelly and Oldham, 1992			autobiography	student teachers (sample size not given)
Wilson, 1992		interview	Written instrument, observation	3 student teachers (secondary)
Cesar, 1995	Questionnaire			331 pupils of grade 7^{th}
Branco and Oliveira, 1996		interview	Observation, written and oral narrative	Two high school teachers and 12 of their students
Burton, 1997		In-depth interview (focus on life history)		70 mathematicians
Knudtzon, 1997				28 student teachers
Allen and Shiu, 1997	5 open-response items			Given to 156 tutor but only 25 responded
Allen and Shiu, 1997	5 closed-response items			Given to 100 undergraduates, but only 40 responded
Colwell, 1998			Group discussion-tell stories about	11 well-educated women

		tell stories about daily use of mathematics.	women

Review of the use of metaphors

The use of metaphors to describe images of mathematics or learning mathematics is not uncommon. Kelly and Oldham (1992) studied the images of mathematics and mathematics education of a group of primary school teachers and student teachers. They found that the metaphor best fitted the overall picture in their sample's image of mathematics and mathematics education was 'a racecourse round which students and teachers had to gallop, generally jumping hurdles (problem solving) on the way'. Likewise, Buerk (1982) noted the metaphors presented by a group of able women who avoid mathematics. These included the following:

> Mathematics does make me think of a stainless steel wall-hard, cold, smooth, offering no handhold, all it does is glint back at me. Edge up to it, put your nose against it, it doesn't give anything back, you can't put a dent in it, it doesn't take your shape, it doesn't have any smell, all it does is make your nose cold. I like the shine of it - it does look smart, intelligent in any icy way. But I resent its cold impenetrability, its supercilious glare. (p.19)

Moreover, using metaphors to describe a personal construct such as images is not rare in the literature. Defining image as a mental construct, Roger (1992) argued that

> throughout history, philosophers and mathematicians have been involved in the ontological questions about the status, 'reality' and existence of mental images. Whichever philosophical standpoint we take, we have to admit two fundamental aspects of this debate: first, we are aware of the power of the human mind to construct mental images; and secondly, our abilities to manipulate these images and use them to inspire creative thought, and many different forms of communication" (p.49).

Therefore, we should expect that some people would use metaphors to describe their images. This is also because it is

> this human desire to make stories about the world in our attempts to come to terms with the physical and metaphysical phenomena we encounter daily has led to a vast fund of metaphor; of manipulating our images to enable us to come to terms in some way with the world we live in. (Roger, 1992, p.50)

Thus, in this study, I argued that it is plausible to conceptualised image as metaphor and to expect the respondents to express their images of mathematics in terms of metaphors.

Review of methods of analysis

With regard to methods of analysis, most studies face similar problems of analysing the variety of different responses given to an open-ended question. Due to the small sample size, most studies (Buerk, 1982 and Hoyles, 1982) just listed the responses. Others have tried to use categorisation (see example, Allen and Shiu, 1997) or look at the link to philosophical beliefs (see example, Mura, 1992).

Thus, Allen and Shiu (1997) suggested five categories in their analysis. These are (a) struggle leading to success, (b) using learned skills, (c) patterns, (d) the unknown and (e) others'. It is interesting to note that the first two categories are related to the learners while the others are related to the nature of mathematics.

Similarly, Mura (1992) analysed the responses to the open-ended question: 'how would you define mathematics?' and 12 categories emerged from her analysis. She explains these categories by relating them to philosophical beliefs such as formalist, instrumentalist or traditionalists. Her finding shows that there was high frequency of the following categories "typical of formalism: an emphasis on abstraction, logic, rigour, notation and symbolism" (p.13) and the next common category was defining mathematics as a model of the real world. However, as she has expected, few mathematicians' images of mathematics come across as "instrumentalist" or "traditionalist" and a few of them indicate mathematics as the study of pattern and problem solving. In addition, she observes that "not only do different persons have different perceptions, but individuals may hold composite views", and "many seem to have little interest in reflecting the nature of mathematics" (p.16). In fact, she found many of the responses were made up of composite views that can be classified into more than one category (for example, the average was 1.8 category per response in her study).

The above studies thus suggest that constructing a suitable set of categorisation for the data might be a suitable way to analyse the variety of data obtained. However, the category has to be grounded or made to emerge and should not be pre-constructed. This is because images are personal constructs and there is no fixed set of images to be identified, and potentially no limits to the images a person might generate. In addition, many people seem to hold composite views of mathematics and it might be difficult to identify one type of image from the others. Thus, it is important to categorise all the responses into multiple categories and to consider all the possible interpretations from a given response. Nevertheless, I am aware that categorising the data will only help me to analyse my data in a more systematic manner, while not ignoring the possible variety of alternative interpretations.

4.2 Rationale or justification of method used in this study

The previous section indicates that many studies on images of mathematics have relatively limited sample size. Most of these studies focused on participants involved in some forms of education such as mathematicians (Mura, 1992), primary teachers and student teachers (Kelly and Oldham, 1992; Knudtzon, 1997); pupils (Holyes, 1982) or adult learners of Open Universtiy (Allen and Shiu, 1997). Therefore, a study with a larger sample size and which covers a wider range of sample, extending beyond those involved in mathematics education might help to better illuminate the public's images of mathematics.

In terms of methods used, the review has shown quantitative methods are mostly used for large samples whereas qualitative methods are used for smaller sample size and more in-depth study of such samples.

Since the main aims of this study is to make a systematic enquiry into the public's images of mathematics and the possible sources of their images, I chose to integrate both quantitative and qualitative methods and carry out the research in two stages. In choosing a quantitative survey for the first stage of the enquiry and a qualitative approach in the second stage, I am hoping to find a marriage of these approaches to maximise the efficiency of my data collection.

Advantage of integration of methods

The integration of both quantitative and qualitative methods is gaining in popularity in recent science and mathematics education research (see Evans, 1994; Niaz, 1997). In a study to investigate adult learners' mathematics anxiety, Evans (1994) uses three types of approach: a quantitative approach, a qualitative case study approach and a qualitative cross-subject approach to collect his data. A cross-subject approach (or cross-case analysis as in Miles and Huberman, 1994) refers to making a comparative analysis between subjects or cases of a study. Evans pointed out the strength of these approaches as follows:

> The quantitative approach is useful when we wish to make comparison across subjects, or groups of subjects, and we aim for some degree of generality.
>
> The qualitative case study approach is useful when we wish to explore the richness, coherence (i.e. not being separated into variables) and process of development of a limited number of cases.
>
> The qualitative cross-subject approach provides an intermediate approach, for cases where it may be challenging to produce comparability across subjects, …, but where some generality in finding is sought. (p.326)

He concludes that, 'rather than polarising the discussion by asking which method is "the best", we can note the relative strengths of each, and attempt to combine the different approaches in a way that is effective for the problem at hand' (p.326). Likewise, Niaz (1997) and many researchers in social sciences (e.g. Bryman, 1988; Hammersley, 1991) support this view and argue that the importance of such integration of methods is that the data collected may compliment and strengthen each other.

On the other hand, other approaches such as case studies might provide a more complete picture of the images of the respondent, yet they are costly in terms of time and resource. In view of the limitation of time and available resources, I proposed to take the advantage of both quantitative and qualitative methods to collect my data. The quantitative approach allows me to get a snapshot of the public image of mathematics, or at least that of a relatively large sample, while the qualitative approach allows me to probe into the possible factors of influence of the images of a smaller sample.

Stage one: questionnaire

In stage one, my aim is to explore the general pattern of the public's images of mathematics and to look for any possible correlation between these images in terms of age, gender and occupational groupings. Therefore an appropriately large sample size is needed so that the number of participants in each subgroup is reasonably representative of the total population. Due to the large sample size and the nature of this study, I opted for survey method using questionnaire as the most suitable approach. This is appropriate, for Kerlinger (1986) has noted, "survey research is probably best adapted to obtaining personal and social facts, beliefs, and attitudes" (p.386). However, I was aware of the limitations of survey methods. Kerlinger (1986) also reminds us that "survey information ordinarily does not penetrate very deeply below the surface. The scope of the information sought is usually emphasized at the expense of depth" (p.387). In view of this limitation, instead of the usual five-point Likert scales, I attempt to structure the questionnaire with a variety of question types, including open-ended question, structured questions with 'yes-unsure-no', 'ranking in order of importance' and choosing as many options described from a large selection. The detailed development of the questionnaire will be described in Section 4.3.

Open-ended question

The main reason for opting to use open-ended questions for investigating the respondent's images of mathematics centre on the nature of the issues to be explored. Images are personal constructs, and these are subtle and complex. Thus, it is difficult to use any simple language to frame the questions in such a way that it will suit all respondents' view. More importantly, I wanted to understand the images of mathematics from the public point of view, rather than comparing them with certain fixed or existing pattern of images. Therefore, I decided to use an open-ended question approach, which allows the respondent to respond more freely, even though I recognised that the responses will be varied and consequently could be more difficult to be interpreted and analysed.

Mura (1992) also supports the advantage of using open-ended question to probe for the respondents' images of mathematics and learning mathematics. She proposes the use of open-ended questions because this method "is able to capture some spontaneous thoughts of the respondents which might be the most salient and this format allows the respondents to express mixed perceptions" (p.4).

Stage two: semi-structured interview by telephone

In stage two, I aim to explore the possible influencing factors that contribute to the public's images of mathematics. I realised that it is impossible for me to probe these factors through structured questionnaire, because of the open-ended nature of the enquiry. Therefore, I need to use qualitative method such as personal interviews. Even though other qualitative approaches such as case study or life history might provide a better insight or more coherent picture of the images of the respondent and their possible causal influences, these methods are costly in terms of time and resources. In view of the limitations of time and resources, I propose to take the middle path of using semi-structured personal interviews, with a reasonable size of sample, about 10% of the total sample.

Strength and weakness of personal interview

I acknowledge that any type of research method always has its strength and weakness. As noted by Tuckman (1972), using interviews to collect data provides us with a chance to access what is 'inside a person's head', and thus it makes it possible to measure what a person knows (that is knowledge and information); what a person likes or dislikes (values and preferences), and what a person thinks (attitudes and beliefs). As the aim of stage two is to explore the possible formative factors of influence on the respondents' images of mathematics, I am probing into a person's attitudes, beliefs and their system of values. These constructs would appear complex and might well be partly tacit. Therefore, a personal interview is deemed to be the most suitable one. Miller (1995) also remarks that, "one of the advantages of interview is the possibility of accommodating spontaneity as well as preconceived and more tightly structured aspects" (p. 29). This is because during interview, we have the chance to clarify questions or responses, which is impossible if only a written structured questionnaire is used.

I am also aware of the potential limitations of survey interviews. Kerlinger (1986) warns us that "the survey interview can temporarily lift the respondent out of his own social context, which may make the results of the survey invalid. The interview is a special event in the ordinary life of the respondent. This apartness may affect the respondent so that he talks to, and interacts with, the interviewer in an unnatural manner" (p.387). However, he also remarks that, "it is possible for interviewers to limit the effect of lifting respondents out of social context by skilled handling, especially by one's manner and by careful phrasing and asking of questions" (p.387). Bearing this limitation in mind, effort has been made in designing the interview questions and the approach used in interviewing. The interview schedule was trial run with two respondents who were known to the interviewer before it was used for the actual sample. I will discuss this in more detail in Section 4.3.

My next problem is the large sample size that I have in stage one. Taking only 10% of the total sample in stage one means having about 60 interviewees in the second stage. Moreover, these participants are distributed around England, making it impossible for me to interview them face-to-face because of time and travel costs. Therefore I had to find an alternative way that is economical in both time and money to carry out my interview. Furthermore, my sample is public adults, most of them are busy people with active careers and social lives. Thus, they might not have much time to spare me. As noted by Groves and Kahn (1979), it is getting more difficult to obtain interviews with the public in recent years. This is because typically more than one adult in a family holds a full time job. This means far more often, adults are not available at home. Consequently, the researcher will have to make an increase number of request calls. However, the problem is "the greater the required number of calls, the more likely it is that the interview request will be met with some reluctance" (Groves and Kahn (1979, p.3). This could be discouraging, as they have found the response rate for some research surveys to be as low as only 50%.

Bearing the above constraints in mind after reviewing the strength and weakness of telephone interview, I have chosen telephone interviewing as my method. .

Strength and weakness of telephone interview

Previous studies (for example: Wiseman, 1972; Lucas and Adams, 1977; Colombotos, 1965; Rogers, 1976), have compared the effect of different modes of data collection, including mail, face-to-face personal, and telephone interviews. Generally they found no difference in response distributions among these three modes. Many of these studies focus on embarrassing and sensitive issues such as abortion, drug abuse, alcohol abuse and family planning. In contrast, some other studies found better responses from telephone interviews (e.g., Coombs and Freeman, 1964) while others found that some respondents are more reluctant to reveal data in telephone interviews as compared to personal interview (e.g., Schmiedeskamp, 1962). Groves and Kahn (1979) offer the warning that most of these studies vary in research design, in the population studied, or in the kinds of data collected, so their results might not be comparable.

Groves and Kahn (1979) carried out a systematic and comparative study on different modes of enquiry. They used the same interview questions in all the three studies: a personal interview survey; a telephone survey with single-stage stratified sample selected by random-digit dialling (RDD), and a telephone survey with multi-stage clustered sample selected by RDD. Their findings highlighted one of the greatest advantage of telephone interview was its cost benefit because the cost of sampling and data collection in a telephone survey was 45-64 % of that of the personal interviews.

However, they pointed out two main disadvantages of telephone interviews over personal interviews. First, there is a tendency to give shorter answers in the telephone mode due to the faster pace of responses to telephone interviews. As a result, quality and completeness of responses might be less satisfactory. This statement, however, is still yet to be verified by further studies.

Secondly, although not statistically significant, there is evidence that there is a greater expressed uneasiness and suspicion among respondents of telephone surveys than those in face-to-face interviews. It is proposed that due to the lack of trust and rapport between interviewer and interviewees in telephone interviews, the interviewees might be less willing to reveal issues that are sensitive or some uncertainties in their lives. In contrast, Colombotos (1965) found greater validity in the telephone interviews concerning sensitive issues because there is a greater social distance between respondent and interviewer that may free the respondent to answer more honestly. Likewise, Nias (1991) concludes that her respondents found they can talk to her more freely in telephone interviews because she was not physically present.

In short, telephone interviewing provides the greatest advantage in terms of time and cost efficiency. As agreed by other researchers (e.g., Miller, 1995; Lavrakes, 1993), conducting interviews by telephone is reasonably more efficient in terms of time and more economical. In addition, as Groves and Kahn (1979) point out, "telephone line goes where interviewers may fear to tread, and reach behind doors that householders may fear to open" (p.x). Therefore, interviews by telephone seemed to me to be the best option for me to reach the general public who would not otherwise be reachable by me, beside the reduction of time expended and the travel cost.

4.3 Development of instruments used in this study

Stage one: Questionnaires

A short questionnaire was designed to collect data on adults' image of mathematics as well as to provide measures of their attitudes and beliefs on mathematics. I chose to use a short questionnaire because previous literature (Sewell, 1981; Buxton, 1981, Colwell, 1998) show that some adult members of the public tend to avoid mathematics-related activities and this could limit the choice of a suitable method for data collection. Therefore, I opted to design the questionnaire short and simple so that it will not demand too much time from the participants (such as less than 5 minutes to complete). Next, the questionnaire was designed to make up of only a single sheet of paper, printed on both sides, and folded in the middle of the page (see Appendix A). Thus, the questionnaire looks like a short pamphlet that I hope will be more appealing to the participants.

The questionnaire was divided into two sections:

Section A consisted of two open-ended questions and 9 structured questions. The open-ended questions (Question 2) asked for participants' images of mathematics and learning mathematics in the form of descriptions, and metaphors or analogies. Initially I hesitated as to whether I should give an example for each of these open-ended questions, as I understand that any example given might bias the responses obtained. However, during piloting, I was asked for an example of an image by a number of respondents. Thus, I decided to give an example of metaphor to act as a trigger as well as to clarify the question. I acknowledge that whatever type of example that I give (such as positive or negative image) might influence the type of answer that I obtain. So I chose to give an example of an image in the form of metaphor, and which was neutral with regard to positive or negative images of mathematics. [See examples in Appendix A]

The nine structured questions were intended as a mean of investigating the following constructs:

I. attitudes - Question 1 (liking) and Question 3 (feelings, self-confidence and anxiety about mathematics);

II. beliefs - Question 5 (belief about mathematical ability); Question 6 (belief about gender difference in mathematical ability);Question 7 (belief about the nature of mathematics) and Question 8 (belief about the importance of school mathematics);

III. images - Question 9 (images of a typical mathematician) and Question 10 (images of how a mathematician finds new knowledge).

Section B aims to collect background information such as gender, age group and occupation. The final item on the questionnaire asked the respondents to indicate if they will be willing to be interviewed further about their responses in the second stage of this study. For those who agree, they are asked to give their contact address and state the most convenient time for contacting. [See sample questionnaire in Appendix A]

Stage 2: Semi-structured interview

Analysis of data from stage one reveals a range of images and general trends of beliefs and attitudes among the respondents. To uncover the possible influencing (formative) factors for their images, beliefs and attitudes, further probing and an in-depth inquiry is needed. I have chosen the semi-structured interview because it allows the interviewer to lead the participants to a focused and systematic inquiry on the proposed topic. At the same time, it also gives the participants some freedom and flexibility in expressing their views and feelings. All interviews were audio taped for analysis.

In designing the questions for interview, I was influenced by Hoyles' (1982) and Brown's (1995) approach. Hoyles (1982) interviewed 14-year-old pupils by asking pupils to recall some significant moments (such as good or bad experience) of learning mathematics in school. Brown (1995) asked her respondents to recall and tell stories about some critical incidents relating to their mathematics class. Hoyles (1982) remarked on the need for "an approach based on the description of real situations rather than the collection of generalities or opinions" and that this was "felt to be more meaningful to the pupils concerned" (p.350). I have adapted these means of probing by asking the respondents to recall their mathematics experiences in school, from primary to secondary.

The interview is proposed to take between 10-30 minutes, as most people will not be able to concentrate more than half an hour in a telephone interview (Groves and Kahn, 1979). A list of questions has been constructed to act as guidelines or prompts for conversation with the participants. It is divided into four sections:

- Section A: refers to the participants' given answers on liking or disliking and probe for the reason of liking or disliking;
- Section B: refers to the participants' responses on the nature of mathematics (their given image) and asked for further elaboration and clarification;
- Section C: refers to the participants' stated most and least enjoyable times in school mathematics and then asks them to recall their mathematics learning experiences in school;
- Section D: asks for any change of views about mathematics since they left school.

Both Section C and Section D were aimed to uncover possible factors of formative influence on the respondents' images of mathematics. [See sample questions for interview schedule in Appendix B].

Open-ended questions

During the process of designing the interview schedules or questions, I have taken into consideration various suggestions and cautions given by researchers. For example, Tuckman (1972) suggests that we could use open-ended questions in conjunction with probes on the part of the interviewer. This is because

> 'Open-ended questions have a number of advantages: they are flexible; they allow the interviewer to probe so that she may go into more in-depth if she chooses, or to clear up any misunderstandings; they enable the interviewer to test the limits of the respondent's knowledge; they encourage co-operation and help establish rapport; and they allow the interviewer to make a truer assessment of what the respondent really believes. Open-ended situations can also result in unexpected or unanticipated answers which may suggest hitherto unthought-of-relationship or hypotheses. A particular kind of open-ended question is the 'funnel'. This starts with a broad question or statement and then narrows down to more specific ones' (p.277).

Therefore, I adopted this approach and designed some of the questions. For example, "You mentioned that you like mathematics, could you please tell me what is it that you like about it?" or "Have you ever had any bad experiences of learning mathematics in school? What was it? Could you please describe or tell me more about it?"

Indirect questions

The next point is asking indirect question instead of direct ones. As commented by Tuckman (1972), a question that is too direct and specific may cause respondents to become cautious, or may direct their answers. As a result, the respondents might tend to give answers that they believe are desired by the researcher. On the other hand, asking indirect questions, such as making the purpose less specific or obvious might lead the respondent to feel less alarmed and thus to produce frank and open responses.

Bearing these warnings in mind, instead of asking the respondent directly what the possible factors of influence on their images are, I attempt to ask indirectly about their mathematics learning experience in school as well as any changes of view about mathematics over the years.

I have found that the question on asking whether their images have changed over time proves to be very useful because it provokes the participants to recall and reflect on their own experience of learning mathematics. In fact, this question seems to promote much more conversation and it also naturally leads the respondent to talk about the possible factors of influence as their images of mathematics changes over time.

Another recommendation made by Brown (1995) is that an effective way of encouraging the respondent to talk at length is by 'summing up' or a simple reiteration such as *So you think that …(repetition)…*at the end of conversation. I have incorporated some of these methods into my interview schedule and found them very useful.

I am also aware of Miller's (1995) cautions about the subjectivity and objectivity of the researcher in interviews. Miller (1995) warns that,

> Familiarity with a situation may lead to some loss of objectivity on the part of a researcher who may be unable to stand back from the situation and to see it from a perspective of distance. Too many aspects of a situation may be taken for granted and it may be difficult to ask naïve questions about situations which are already familiar. On the other hand, Hockey (1993) suggests that an insider may have a rapport with informants which may be lacking in a stranger. There may be certain linguistic and cultural familiarity which enables the researcher to understand the situation and interaction more readily. (p.30)

As a foreigner (Malaysian), I find myself having the advantage of being new to the culture of my UK respondents. This helps my objectivity as a researcher. On the other hand, to some extent, I might be lacking in terms of linguistic and cultural knowledge, and hence to have misunderstood responses and cues. Consequently I might be unable to fully understand the interview situations or interactions. Nevertheless, to minimise this limitation, I am constantly prepared to clarify my understanding with my respondents as well as my British colleagues, and my supervisor whenever there is any doubt about my interpretations or understanding due to linguistic or cultural differences.

4.4 Pilot study

Stage one: questionnaires

I piloted the first draft of the questionnaire among five of my colleagues and friends at Exeter, comprising of four postgraduate students and one technician at the Research Support Unit. My aim was to clarify any ambiguity in wording or sources of misinterpretation of the questions. Taking into account the suggestions and comments made, as well as many discussions with my supervisor, I modified and revised the questionnaire, and it became the revised questionnaires as shown in Appendix A. The revised version was then piloted to a sample of 32 public adults, randomly selected on High Street, Exeter. The second piloting was aimed to survey the response of the public toward this data collection approach. I found that most people that I approached were willing to answer my questionnaire. Although I met with a few refusals, I managed to collect 32 sample within 5 hours during a day visit to the High Street. I found this encouraging.

Initially, some respondents mistook me as carrying out market survey. After I explained that I am a university student conducting a research on the public, they were then more willing to respond. This prompted me to add the university logo to my questionnaire in the revised version.

Many of these first respondents found the questionnaire interesting, especially the open-ended question on images and the example given. They managed to complete the questionnaire in between 5-10 minutes. This confirmed that the length of the questionnaire was about right, given my aim not to detain people for too long.

Another suggestion given by a university lecturer was on the question on beliefs about gender. Initially the question was 'Do you think men are better in mathematics than women?', it was commented that this question sounded biased and insensitive, so I changed it to be 'Who is better in mathematics?' and given three choices: men, women or both/the same.

Stage two: semi-structured interviews

I also piloted the semi-structured interview schedule with four participants at Exeter. They were two research students and two student teachers, all friends and housemates. These pilot interviews had been conducted to test and evaluate the questions and to allow refinement of interview and analysis techniques.

4.5 Sampling and administration of data collection

Sampling for stage one

Due to the constraints of time and resources, I chose to use a combination of stratified sampling and opportunity sampling (predominantly the latter). The benefits of stratified sampling are that it allows a more or less representative sample to be constructed to represent the population, as well as permitting the stratification of the sample according to further criteria of interest (Bryman & Cramer, 1990). My criterion categories are firstly the general public who are not involved with mathematics as teachers or students, including students (non-maths) and teachers (non-maths). Secondly, the public who are directly involved with mathematics teaching, both as mathematics students and as mathematics teachers.

In order to obtain a wide selection of the public within the constraints of the study, the locations for data collection were public places in and around Exeter including the high street, bus and train station, visitors to the riverside and quay, the cathedral, persons on the university campus and parents at a school open evening.

I was fully aware that the sample is essentially an opportunity sample, and only those who agreed to participate were sampled. To compensate for the former, efforts were made to stratify the sample, by consciously seeking out persons who appeared to the researcher to come from under-represented categories in terms of gender, age grouping, and occupational grouping. In this way the overall sample was almost gender balanced and each age group and several of the occupational groups contains 5% or more of the total sample. I acknowledge that the lack of a properly stratified random sample is a weakness, necessitated by the constraints within which the study was undertaken. However there is no apparent reason why this should skew the sample with regard to their images of mathematics.

Social surveys in Britain which involve the public mostly use one of these two classifications: (a) Social Class based on Occupation (also called Registrar General's Social Class) and (b) Socio-economic Groups (The Office of Population Census and Survey, 1990a). For this study, I chose to adopt the former, as there are only six classes as compared to 17 in the latter. For this study data obtained from the public was classified by occupational type as follows:

1. Professional
2. Managerial and Technical
3. Skilled (both manual and non-manual)

4. Unskilled and partially skilled occupations.[1]
5. Others (unemployed, retired and unclassifiable occupations).

The sample was also (self) classified into four age groups, namely, the young people group (age between 17-20); the young age group (age between 21-30); the middle age group (age between 31-50); and the older age group (over 50 years old). The ages were grouped in such a way that the opinions of the sample might loosely reflect experiences of different stages in the evolution of the mathematics curriculum in England and Wales. Generally, the older age group (51+) would have experienced their statutory schooling in the era of traditional mathematics before the 'modern maths' reforms became widespread in the early-mid 1960s; the middle age group (31-50) would have studied in the era of 'modern maths', the young age group (21-30) would have studied in the post-Cockcroft era[2] and the youth group (17-20) will have studied in the era of the National Curriculum. The different age groupings would thus be expected to have undergone different school mathematics programmes which might affect their images of mathematics differentially, although their subsequent work, educational and other experiences (e.g., parenting) would also possibly impact on their images of mathematics. This was my initial motivation to classify the sample by curriculum changes. However, the results of my analysis showed that there was no consistency or any general trend linking the differences in curriculum changes with the public's image of mathematics. Thus, I have decided not to pursue these speculative and tentative links any further. Table 4.2 shows the distribution of the collected sample size by gender, age, and occupational groupings.

[1] For the purposes of this small-scale study, I combined the partially skilled and unskilled occupational groupings into one category

[2] The Cockcroft Report (1982) emphasised problem solving and open-ended investigational activity in mathematics, and resulted in the inclusion of 'extended pieces of work' and coursework reflecting these learning styles in the General Certificate of Secondary Education examinations introduced in 1985.

Table 4.2: The sample distribution according to age, occupation and gender

		Maths teachers		Maths students		Non-maths teachers		Non-maths students		Professional		Managerial & technical		Skilled		Unskilled		Others		Row total	% by age
	Gender	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M		
	17-20	0	0	12	11	0	0	29	27	0	0	0	0	4	6	4	4	1	2	100	18.3%
age group	21-30	5	1	13	8	7	0	33	22	4	14	15	13	10	14	7	2	1	2	171	31.2%
	31-50	10	11	0	3	14	7	2	3	9	25	29	13	18	15	21	12	0	7	199	36.3%
	50 & above	2	0	0	0	5	5	0	1	1	10	9	6	6	8	6	9	3	7	78	14.2%
	Total	17	12	25	22	26	12	64	53	14	49	53	32	38	43	38	27	5	18	548	
Total F+M		29		47		38		117		63		85		81		65		23		548	
% by occupation		5.3%		8.6%		6.9%		21.4%		11.5%		15.5%		14.8%		11.8%		4.2%			100%

Administration of questionnaire

The data was collected during summer in 1997 over duration of one and a half months. I myself collected four fifths of the data while my friends and colleagues collected the other one fifth. The questionnaire is self-explanatory, so allowing others to collect some of the data should not adversely affect its quality. Table 4.3 shows the frequency distribution of data collected at the different locations.

I distributed the short questionnaire to any potential respondents that I met on public places. After introducing the aims of my study, I invited them to complete the questionnaire immediately. About 68% of the data were collected through this method. About 20% of the questionnaires were collected through my friends and colleagues from their friends and relatives. While 8.4% of the data were collected immediately after a school open evening for parents, 3.6% of them were collected from the participants before the start of a mathematics seminar for teachers.

Table 4.3: Frequency distribution of sample by location/source of data collection

Location/source	Frequency	Percentage
University campus	193	35.2%
High Street	120	21.9%
River quay	52	9.5%
Museum	4	0.7%
Bus station	3	0.6%
School open evening	46	8.4%
Mathematics seminar	20	3.6%
Through Friends	110	20.1%
Total	548	100.0%

Some observations and problems encountered during stage one data collection

As in any data collection, I inevitably encountered some problems that added to the limitation of my study. I attempted to solve them as far as possible. However, some of these problems helped me to reflect and actually gave me better insight into the public's images of mathematics. These problems are as follows:

1). Some potential respondents refused to answer the questionnaire when they were told it is about mathematics. I presume that these are mostly people who dislike mathematics. There were one porter and one old lady who withdrew themselves after reading the first question asking whether they like mathematics or not. These incidents showed that those who dislike mathematics might tend to avoid any activity that involves mathematics. This is not uncommon, and the same reaction was experienced by Sewell (1981) in her enquiry on public adults' use of mathematics in everyday life. Similarly, in the National Numeracy Survey (Basic Skill Agency, 1997), up to 13% of the United Kingdom sample gave outright refusal to undertake the task even before they were being shown the types of numerical calculation involved. Although I did not keep formal records of those who refused to answer the questionnaire, I am confident that the overall refusal rate was below 10%.

I was the gatherer of 80% of the data. I am a Malaysian woman of below average height, small build, and I presented myself as a student. I feel my physical appearance might have 'read' as unthreatening which might have contributed to a high response rate. (Note that the other 20% of the data were collected by my friends and colleagues through personal contacts and they did not report any refusals.)

2). A few categories of the sample such as the skilled and unskilled workers of the youth group (aged 17-20), were under-represented as I had a problem locating enough of them. Nevertheless, I attempted to include as many of them as possible through the assistance of my friends and colleagues. I also attempted to go to places that are frequently visited by youth such as pubs, the job centre and amusement arcades (included into the sample of High Street).

3). I found the older age group, who reported dislike mathematics, needed the most persuasion and reassurance before they would answer the questionnaires. When I told them it was about mathematics, some of their immediate reactions were as follows:

> *"I don't understand maths"* (an old man at the Bus station);

"I don't like maths" (an old lady at the Bus station);

"These questions are not sensible" (an elderly porter at campus);

"I don't want to do it!" (a middle-age porter at campus);

"These questions are not for us, you better ask the students" (an old lady on the High Street).

In addition, after completed the questionnaires, many of them also remarked that, 'I don't think my answer will help you much.'

These observations seem to indicate that many of the old age groups, especially those who reported dislike of mathematics, displayed a rather negative attitude towards mathematics. They also showed very low self-confidence about their own mathematical abilities.

Sampling for stage two

As discussed earlier, the sampling method employed in this study was by opportunity and thus the sample chosen for the follow-up interviews was partly predetermined. This is because only those agreed or volunteered to be interviewed and could be contacted by telephone were interviewed.

Tables C.1 to C.3 (see Appendix C) show the sample distribution of those who agreed to be interviewed and those finally been interviewed respectively. From a total sample size of 548, about 40% [N=222] of them agreed to be interviewed, but 62 out of the latter were selected for interview.

As one of the main objectives of this study is to explore the possible factor of influence of positive and negative images of mathematics, I decided to divide those agreed to be interviewed into two general groups: those who expressed liking and those who expressed disliking of mathematics. There were 36 of those who expressed liking and 26 of those who expressed disliking of mathematics selected. (see Tables C.4 and C.5 in Appendix C)

Secondly, I aimed to explore whether there was any relationship between the possible factors of influence of images of mathematics and the background variables such as gender, age groupings and occupational groupings. Thus, I attempted to choose one subject from each of the sample categories as shown in Appendix C. However, I was again restricted by the sample itself because I could only interview those who volunteered to be interviewed and those who could be contacted by telephone. Inevitably, one of the limitations of this sampling method is that the sample included is not properly representative of the population and thus the results cannot be fully generalised. However, an attempt was made to stratify the sample as much as possible to maximise the generalisability. I was interested in exploring and gaining a better understanding of the British public adults' images of mathematics and their possible sources of influence than to have a general representative view of mathematics.

Administration of telephone interviews

The telephone interviews were administered during early November to mid-December of 1997. The data was thus collected over a period of one and a half months. Each interview lasted from 4 minutes to 50 minutes but the average duration was 12 minutes.

Response rate

To increase the response rate, I asked the respondents to state their most convenient time for contact during the first stage of data collection. I tried to contact them at the stated time, but inevitably, sometimes I needed to make a few contacts or to make an appointment before I could interview them. In general, asking the respondents to state their most convenient time for contact has greatly increased the chance of getting hold of them.

Once contacted, the respondents were interviewed immediately, unless the timing was inconvenient for them. In that case, another appointment was made. I found that immediate interviewing like this decreased the chance of rejection or refusal from the respondents. Many of them preferred to be interview there and then. They agreed that it was difficult to find another suitable time because the time that I contacted them was mostly their most convenient time. Generally, this was in the evening or after their working hours.

Without doubt, immediate interviews like this caught some respondents unprepared and this might produced some anxiety, fear, avoidance or defensive reactions in the beginning of the interview. But once the interview started and the respondents were made to feel at ease, most interviews ran smoothly from then on. There was one or two who got carried away and talked for more than half an hour.

The shortest interview was recorded as 4 minutes while the longest was 55 minutes. Most of them were within the range of 8 to 30 minutes. The average time recorded for the 62 interviews was 12 minutes.

One advantage of talking through the phone is that the respondents might not realise that the conversation was recorded, though their permissions were sought before the start of the interview. However, without seeing at a tape-recorder in front of them, some people might forget about its existence after a while. This might reduce the anxiety or fear effect of the recording.

By talking through the phone as opposed to talking face to face, some personal barriers might be broken down more easily, in the sense that some people feel freer to talk to a stranger or an imagined speaker. However, I recognised that the reverse can also be true. Some might find it strange and might behave more defensively when talking to someone on the phone, as compared to face to face.

Problems encountered during the telephone interview

Some problems encountered during the telephone interview were:

1. *Difficulty in locating the respondents*. They were either not available or had moved house. I attempted to locate them by phoning them several times or locating them through different sources such as through their friends or members of their families. This occurs most frequently among the students and the student teachers.
2. *Poor sound quality of some of the recorded telephone conversations*. This could either be due to the respondents speaking softly or poor telephone connections. I attempted to solve this problem by inviting the respondents to speak louder or by redialling the respondents, in the latter case.
3. *Overlapping of speech in the telephone conversation because of the lack of visibility of facial expression between the interviewer and the interviewee.* This problem was

solved by allowing a longer waiting time or by expressing some kinds of tones of agreement such as 'yes' or 'hmm'.

4.6 Validity and reliability of the study

As discussed earlier, images are personal constructs and this study is exploratory and interpretative in approach. Inevitably, I acknowledge that this study has its limitations in terms of validity and reliability of the data collected from both quantitative and qualitative methods. However, I have employed a number of techniques to establish and enhance the validity and reliability of the quantitative data as well as the trustworthiness of the qualitative data (as suggested by Lincoln and Guba, 1985).

Validity of the quantitative data

First of all, I chose to adopt a broad interpretation of the term 'image of mathematics' to include a wide range of concepts that are related to studies on images of mathematics. In particular, I conceptualised the term 'image of mathematics' to include four main constructs: (i) image as attitudes and feelings, (ii) image as beliefs about mathematics, (iii) image as metaphors, and (iv) image as related to past experiences. (See detailed conceptual analysis in Chapter 3).

To maximise validity, I used multiple questions to tap into each construct. For example, the construct 'attitude to mathematics' was investigated through question one (asking for liking or disliking of mathematics) and question 3 (asking for respondents' feelings when they thought of mathematics learning in school, including enjoyment, self-confidence and anxiety about mathematics). I found the responses to these two questions were correlated with a moderately high coefficient of 0.605 (reported in Chapter 5, Section II.7). Thus, I would argue that the data collected were valid because responses to both question 1 and question 3 were largely consistent and convergent.

In addition, the responses of a subsample (about 10% of the total sample) were further validated in the follow-up interviews. Based on the respondents' responses to the question on liking of mathematics, the respondents were asked to reconfirm their attitudes to mathematics as well as their reasons of liking or disliking of mathematics. Further analysis shows that out of the 62 interviewees, 60 of them confirmed their responses as on the questionnaire, but two of them restated their views slight differently. For example, in the questionnaire given, a cleaning lady responded that she liked mathematics. However, in the follow-up interview, she stated that "I don't particularly like them [mathematics] but I don't mind them. ... I don't dislike them but I don't use them everyday" (R369, text-unit 3). Similarly, one IT student stated that he disliked mathematics but in the follow-up interview, he explained "I think it is more, not much that I do not like mathematics, it is just I am not good at it" (R107, text-unit 3). Perhaps, this change of responses indicates there is ambiguity in the respondents' answer to the question on liking. I have acknowledged this limitation in the analysis of the results. In spite of this limitation, I argue that the data were valid because the vast majority of the subsample reconfirmed their responses given on the questionnaire.

Reliability of the quantitative data

As the sample used in this study consisted of public adults chosen largely by opportunity, it is not possible for me to use a test-retest technique to check for the reliability of the quantitative data. Thus I opted to use a statistical reliability test such as Cronbach-Alpha to test for internal consistency of the relevant data. I have tested the internal consistency of the responses to question 3 (on feelings to mathematics). These questions are made up of multiple items, but measure a single trait or dimension. The results are displayed in Table 4.4.

Table 4.4 Reliability Test on questions 3

Question	No. of cases	No. of items	Alpha coefficient
3	548	14	0.7843

As shown in Table 4.4, there were 14 items in Question 3, with dichotomous answers (yes or no) and a Cronbach Alpha coefficient of 0.7843 was obtained. According to Bryman and Cramer (1997), the coefficient should be more than 0.8 to be considered as highly reliable. As 0.78 is reasonably high, thus the 14 items were considered to be internally reliable.

However, the Cronbach Alpha test is only useful for question with multiple items and that measures a single trait. Thus, for example, even though Question 7 is made up of 6 items, these aim to measure multiple dimensions of the nature of mathematics. Therefore, Cronbach Alpha test is not suitable for checking its internal consistency as different dimensions are involved. Similarly, as the rest of the questions on the questionnaire are made up of single items, a statistical reliability test such as Cronbach Alpha is again not suitable for use here.

In spite of the above limitations, I argue that the data is reliable because the majority of the respondents still retain their views when they were interviewed in the follow-up interviews, which were conducted three months after the questionnaires. Only a minority of the sample (for example, less than 3% of the respondents) restated their responses slightly differently, and this is only for a certain part of the questionnaire (such as question 1).

Trustworthiness of the qualitative data

For the qualitative data, Lincoln and Guba (1985) suggest using the term 'trustworthiness' as a more suitable and equivalent term of validity and reliability for the quantitative data. According to them, 'trustworthiness' includes four main criteria: 'truth value', applicability, consistency and neutrality. In other words, it is imperative to establish the 'creditability', 'transferability', 'dependability' and 'confirmability' of the study, which is 'the naturalist's equivalent to the conventional terms "internal validity", "external validity", "reliability" and "objectivity"' (Lincoln and Guba, 1985, p.300). Thus, I attempt to establish the trustworthiness of my qualitative data by adopting some of the techniques suggested by them. I justify and describe them in the following section.

Apart from the quantitative data, I have qualitative data that is comprised of responses to the two open-ended questions and the interview transcripts. As these responses were textual, they were opened to multiple interpretation. I am fully aware that as people communicated their images of mathematics to me in terms of words or metaphors, I then had to interpret them in terms of my own experience and constructs. Thus I acknowledge that there is the possibility of using different frameworks for interpretation of the same data. For example, one of the metaphors given was: " learning mathematics is like going to sleep." I interpreted it as " learning mathematics is boring and not exciting that make one feels like going to sleep". However, one of my colleagues interpreted the same metaphor as "an enjoyable experience", as according to her, she was very tired from her works and going to sleep was an enjoyable experience for her. This raises problems concerning the validity of our interpretation and data analysis.

To overcome this problem, a number of measures have been taken to validate my interpretation. First, all ambiguous data was eliminated unless independent confirmation of the interpretation could be made. For example, one response to the question on the image of mathematics was 'maths is a snail shell in the garden' (R117). It was discarded because it opens up to too many possible interpretations and it was not possible to get further confirmation because the respondent did not agree to be interviewed in the second stage of this study. On the other hand, another response given was "maths is pen and paper" (R239) which is equally ambiguous as the first one. However, it was possible to reconfirm and clarify its meaning with the respondent because she agreed to take up the follow-up interview in the second stage of the study.

Second, an attempt was made to classify the textual responses into as many categories as they can be represented in, because some responses contain composite views or mixed feelings. In order not to lose the richness of the data, each response was coded into one to three different categories or subcategories. For example, the response given: 'mathematics is a complicated but interesting subject' (R360) is coded into three

Table 4.5: Frequency of response categories for images of mathematics and learning mathematics

No. of categories responses fall into	One	Two	Three	More than 3	Discarded/ no response	Total
Images of mathematics	270 (49.3%)	178 (32.5%)	57 (10.4%)	7 (1.3%)	36 (6.5%)	548 (100%)
Images of learning mathematics	226 (41.2%)	199 (36.3%)	29 (5.3%)	12 (2.2%)	82 (15.0%)	548 (100%)

subcategories: Code 111: interesting, Code 411: a discipline or subject, and Code 415: complexity.

I have chosen to include up to only the three most prominent categories because I did not want to over-represent the responses into a category. As displayed in Table 4.5, more than 70% of the responses could be coded into one or two categories while less than 10% of them could be coded into three categories. However, only less than 2% of the responses could be coded into more than three categories, thus I did not include the fourth category as I have considered them to be negligible.

In addition, I tried to interpret the responses holistically and always looked for confirmation of meaning by taking into account their responses to both image of mathematics and image of learning mathematics.

In the whole process of categorisation and re-categorisation, I realised that it would be naïve for me to think that I could avoid personal bias and personal values during interpretations of my data. To minimise this personal bias and prejudice, the data was also cross validated by systematic triangulation.

Firstly, the data was cross validated with four validators: two experts in mathematics education, one expert in research methodology and one postgraduate research student. Their ages range from 29 years old to 60 years old. All of them have lived in Britain for more than 10 years, ensuring that they are familiar with the British culture, society and language. They were given the list of categories with verbatim examples taken from the data. We discussed and readjusted some of the categories according to our interpretations of the data. We then come to a compromise that resulted in a modified list of categorisation of the data. This process was repeated with each of the four validators. However, only one of them validated the complete data while the other three validated parts of the data. As a result, the inter-coders agreement between the former and mine was 79% and 83% (in terms of percentage agreement) for image of mathematics and image of learning mathematics respectively.

Secondly, this categorisation of data was also partly validated during the telephone interviews at the second stage of the study. 62 out of the 548 sample interviewed were asked to explain further their image of mathematics and learning mathematics. They were also asked to verify whether the interpretation and categories assigned to their given metaphors or descriptions of images agreed (or did not agree) with the respondents' original meanings. All except two of them agreed that their responses matched with the assigned categories.

Among the two, one was a primary teacher who gave her image of mathematics as 'can be fun but also a problem' (R542). Initially, I coded her responses in the category of 'enjoyable' and 'difficult'. During the interview, I have the chance to clarify with her:

> I: 'You mentioned that mathematics is 'can be fun but also a problem', could you please explain further?
>
> R542: It is like a puzzle.
>
> I: What do you mean by 'problem' then?
>
> R542: It is like a puzzle that needs to be investigated.
>
> I: So could I say that when you said mathematics can be fun but also a problem, you did not mean that you find mathematics interesting but sometimes it is difficult?
>
> R542: No, not emotionally. But you might find it difficult when you can not find the solution.
>
> (Text-unit 6-11, R542, female, age group 31-50, non-maths teacher, likes maths)

Thus, I realised that she refers the term 'problem' to 'puzzle or problem to be solved' and not 'difficulty in mathematics'. Subsequently, I have recorded her responses into three categories: 'enjoyable', 'problem solving' and 'puzzles and games'.

The second respondent was also a teacher who gave a metaphor as his image of mathematics: mathematics is 'peaches and cream - solid basic sweet effect ' (R544). At first, I coded it in the category of 'beauty of mathematics'. During the interview, we have the following conversation:

> I: You mentioned that mathematics is 'peaches and cream - solid basic sweet effect', could you please explain what you meant by this metaphor?
>
> R544: Yes, It seems to me that people that don't like it, see it as a bit frightening and horrific, they got a hang up because in the past, they always failed to come out with a right answer. If you got a fairly open-ended mind with regard to things like maths and science, then you won't ended seeing it as necessary having to come out with a concrete conclusion. So, that aspect of it I don't find any of it frightening. In the same way that if you use the metaphor like peaches and cream as oppose to

> hmm... something like fish and chip, you actually like fish and chip because it is better taste that you get with vinegar and stuff like that. You see the difference? That is how I will make the comparison. I suspect that people who don't like it, hmm, would like much vinegar on their fish and chip. Ha! Ha! [laughter]
>
> I: When you said 'peaches and cream', do you mean it has a flat taste as compare to fish and chip?
>
> R544: Ha! It is enjoyable as opposed to something that might not be very enjoyable at all.
>
> (Text-unit 8-11, male, over 50, non-mathematics teacher, likes maths)

Therefore, after the interview, I have recorded his response to the category of 'enjoyable'. The possibility of misinterpretation like the above also prompted me to validate my data with a wider audience. This is where I attempted my third layer of validation.

Thirdly, parts of the data together with the categories were validated by 15 participants in a national mathematics education conference (BSRLM). The participants were given the list of categories and 20 sample responses in the form of metaphors or descriptions of the images of mathematics. After an explanation of the category chart (as in Figure 5.4 but earlier version), the participants were divided into small discussion groups and given 15 minutes to categorise the 20 sample data according to their own interpretations. They were encouraged to create new categories if they felt the suggested list of categories was not adequate for the data given. After the group discussion, the category assigned by the researcher and the participants were compared. Only four items out of the 20 sample data were not matched. A few new categories such as 'impossible' emerged from the discussion and many more multiple categorisations were suggested for each item of data in the sample. Therefore the category chart was further modified and readjusted in the light of these suggestions. As a result of these three layers of validations, the final chart of categories for the images of mathematics and learning mathematics of the sample were developed and is shown in Figure 5.4 and Figure 5.5 respectively (in Chapter 5).

Cross-validation of interview data

I have used my interview data to serve a few purposes. The first two sections of the interview were used to clarify with the respondents as well as to validate the data collected in the questionnaire. This indirectly serves to enhance the validity and reliability of the data collected by questionnaire. However, the last two sections were aimed at collecting information relating to the respondents' mathematics learning experiences in school and the possible factors influencing their views or images of mathematics.

To ensure that the last two parts of the interview data are equally trustworthy, I have employed the technique of 'triangulation by investigator' (see Denzin, 1970; Cohen & Manion, 1994)). First of all, I arranged all the 62 interview transcripts according to the respondent's identity number (assigned by sequence of response to the questionnaire). I chose randomly four of them by taking the 20th, 30th, 40th and 60th of the interview transcripts. I printed out only parts of the interview data that pertained to the last two sections of the interview schedule and gave them to two of my colleagues, both full time research students. I also provided them with a separate list of categories that I have used to analyse the data. I asked them to index the data according to the list of categories. However, they were encouraged to suggest new categories if they felt that the suggested list was not adequate for the data.

After they had completed the indexing, both their lists and my list of indexing on the same data were compared to see the degree of matching or corresponding. As a result, there was an average of 90.5% of matching between the three lists. Where there was disagreement, the validators selected additional categorisations rather than rejecting my interpretations. This high measure of agreement confirms the trustworthiness of my interpretations and suggests that the data is largely valid and objective.

To conclude, even though I have justified my choice of the sample and the methods used in this study, I acknowledged that there are still problems and limitations that I have to bear in mind when I analyse my data and report my findings in the next chapters.

Chapter 5

Findings of Stage One

This chapter lists the objectives for the first stage of this study, and reports the results of analysis of data collected at this stage.

5.1 Objectives of Stage One of the study

The first stage of this study aims primarily to make a general survey of the public's images of mathematics. Therefore, more specifically, the two main objectives of this stage are:

1. To explore and identify the range of images, beliefs and attitudes towards mathematics of a selected sample of the public adults, and
2. To investigate any correlation between the range of images of mathematics and social divisions in terms of gender, age and occupational groupings.

5.2 Analysis of questionnaire data

The response rate to the questionnaire was high because out of every twenty people that I approached on the street or campus, only one or two refused to answer the questionnaire. Although no proper records were kept of this, I am confident that the refusal rate was below 10%. Among those questionnaires collected, only 10 questionnaires were discarded. This is because three of them were answered by respondents below the age of 17 years old while the other seven by non-British.

All the data collected were analysed using the SPSS for Windows version 6. Except for the responses to Question 2, all the responses to the other nine questions asked in the questionnaire were keyed in as numeric variables. As these variables were either nominal (e.g., gender, age group) or ordinal (e.g. reported liking, beliefs about mathematical ability), I used mainly frequency counts and cross-tabulation to analyse and display these data. In contrast, the responses to Question 2, which consisted of two open-ended questions, were keyed in as string variables because the data collected were textual. I then analysed them qualitatively as I have discussed in Chapter 4 (under the Section 'trustworthiness of the qualitative data'). I shall give an overview and detailed descriptions of the responses to these open-ended question later in this Chapter (see Section 5.3 III).

5.3 Results and findings

The results and findings are displayed and described in the following subsections:

I. Reported liking of mathematics

II. Expressed feelings towards learning of mathematics

III. Images of mathematics and learning mathematics

IV. Espoused beliefs about mathematical ability and gender differences in mathematical ability

V. Views about the importance of school mathematics

VI. Beliefs about the nature of mathematics

VII. Public images of mathematicians and their work

In each subsection, comparisons are made between genders, and among different age and occupational groupings.

I. Reported liking of mathematics

I.1 The whole sample

The overall finding of the study shows that more than half (53.8%) of the sample responded that they like mathematics and one third of them stated that they do not like mathematics. This result is shown in Table 5.1.

In addition, Table 5.1 shows the overall results with mathematics teachers excluded from the total sample, as they might have a distorting effect. The differences are found to be marginal. The presence of the mathematics teachers affects the results by one or two percentage points only.

These results challenge the widespread myth that the majority of the public dislike and have negative attitudes towards mathematics at least with regard to this sample, since a

Table 5.1: Percentage of reported liking of mathematics by whole sample and by gender

Reported liking of mathematics	Whole sample	Gender	
		Male	Female
	N=548 (N=519)	n=268 (n=256)	n=280 (n=263)
Like	53.8% (51.8%)	56.0% (53.9%)	51.8% (49.8%)
Unsure	13.1% (13.9%)	14.2% (14.8%)	12.1% (12.9%)
Dislike	33.0% (34.3%)	29.9% (31.3%)	36.1% (37.3%)

Note: Figures in parentheses have mathematics teachers excluded.

substantial majority of the sample claimed to like the subject. The issue of the representativeness and generalisability of these data will be discussed later in Section I.5.

There are noticeable but small differences in measures of liking of mathematics by gender, with 4.2% more males than females reported a liking of mathematics, and with 6.2% more females than males expressing dislike. Although the males in this sample seem to have slightly more positive attitude than the females, a second widespread myth that females have much more negative attitudes towards mathematics is also challenged by these results, at least for the sample studied.

Although the largest group within the sample reports a positive liking of mathematics, it should not be overlooked that a sizeable minority of a third of the sample reports a dislike of mathematics. This does give cause for concern, given that the statutory requirement is for regular (almost daily) study of mathematics from the age of 5 to 16 years, and yet subsequently in a third of the population (in this sample, at any rate) end up with a negative attitude towards the subject.

I.2 Among different age groups

The reported results on the liking of mathematics were tabulated by age group. However there is a distorting factor due to the presence of mathematics teachers in the sample. Although the middle age group (31-50) of the raw data shows the highest score in reported liking, the largest subgroup of mathematics teachers also falls within this age group. Because all the mathematics teachers within this age group reported a liking of mathematics, their presence causes a distortion of the results. Therefore, I have the shown results in Table 5.2 with the mathematics teachers excluded (results in parentheses include the mathematics teachers).

Table 5.2: Percentage of reported liking of mathematics by age group

Reported liking of mathematics	Age group			
	17-20 n=100	21-30 n=162 (n=171)	31-50 n=177 (n=199)	50 & above n=76 (n=78)
Like	41.0%	51.2% (51.5%)	59.3% (63.3%)	50.0% (51.3%)
Unsure	15.0%	14.2% (14.0%)	13.6% (12.1%)	11.8% (11.5%)
Dislike	44.0%	34.6% (34.5%)	27.1% (24.6%)	38.2% (37.2%)

Note: Figures in parentheses have mathematics teachers included.

Table 5.2 shows the results for four age bands and includes the overall results for the sample with mathematics teachers excluded, as a mean for reference. Although there is no overall trend linking age group with reported liking of mathematics, there are striking differences among the different age groups. The middle-aged group (31-50) has the highest percentage of reported liking of mathematics, almost 60%, while the young people group (17-20) has the lowest, just over 40%. This is a major difference.

I.3 Among different occupational groupings

There are differences in reported liking of mathematics according to the five occupational groupings used here, however some caveats and exclusions are needed in presenting the results. Students (both mathematics and non-mathematics) are considered to be economically inactive persons and are thus excluded from the occupational grouping. In addition, mathematics teachers would distort the overall results on the liking of mathematics positively, so this group was excluded in the occupational groupings. However teachers (non-mathematics specialists) are included. The excluded groups will be analysed separately and reported later in Section I.4.

Table 5.3: Percentage of reported liking of mathematics by occupational group

Reported liking of mathematics	Occupational group				
	Professional (n=63)	Managerial and technical n=123 (n=85)	Skilled (n=81)	Unskilled (n=65)	Unemployed and others (n=23)
Like	73.0%	55.3% (49.4%)	43.2%	41.5%	39.1%
Unsure	11.1%	13.8% (16.5%)	12.3%	18.5%	26.1%
Dislike	15.9%	30.9% (34.1%)	44.4%	40.0%	34.8%

Note: Results include non-mathematics teachers but exclude mathematics students and teachers (results in parentheses exclude non-maths teachers as well).

Table 5.3 shows the different levels of reported liking and disliking of mathematics among the five occupational groupings considered. In performing this analysis, I had no expectations of any pattern among the different occupational groupings, and had no reason to anticipate that some groupings would have results markedly different from the others. Therefore, it is interesting to observe that there is a decrease in reported liking of mathematics from the highest to the lowest occupational grouping. The professionals seem to like mathematics the most (over 70% reported liking) but the unemployed and others the least (under 40%). Thus in this sample, reported liking of mathematics correlates with social class (as defined by occupational grouping).

It is also interesting to notice that among the different occupational groupings, skilled workers rank the highest in dislike of mathematics while the professionals the lowest. There is a striking disparity between the disliking of mathematics as reported by the professional grouping and skilled grouping, with reported dislike being almost three times more prevalent among the latter (44.4%) than in the former (15.9%). This is a surprising result because it might be supposed that many skilled workers use mathematics in relation to their work, and that this might lead to more positive reported attitudes. Again, one might reasonably suppose that the higher levels of occupation would have had more success in school examinations (including mathematics), and would have engaged in more extended academic post-school studies. But there is no reason to suppose that more extended academic study would necessarily correlate with positive attitudes to mathematics. Once again, such considerations are purely speculative and there is no basis for explaining the variation in responses.

I.4 Reported liking of mathematics of teachers and students

Teachers and students of mathematics have been the target of most studies on mathematics attitude (see extensive reviews by Aiken, 1970, McLeod, 1992, 1994; Ma & Kishor, 1997) because of their direct involvement in the teaching and learning of mathematics. So I thought making a comparison between them. For the purposes of comparison, I include non-mathematics teachers and students as well. The results are displayed in Table 5.4.

Table 5.4 shows very high reported liking of mathematics among teachers and students of mathematics. One would expect this as the mathematics teachers and students have themselves chosen mathematics as their teaching or study specialism. Thus in this context it is worrying that any of these mathematics specialists should report that they dislike mathematics. Over 10% of the mathematics teachers reported a dislike of the subject, as do a smaller proportion of the mathematics students. However the sample sizes are so small so that the actual number of teachers and students involved are 3 and 2, respectively, so no significance can be attached to these figures.

In comparing the remaining results in Table 5.4, between the non-mathematics teachers and non-mathematics students, the result shows that 31.6% more of the non-mathematics teachers than the non-mathematics students, claimed to like mathematics. Almost one half of the non-mathematics students reported a dislike of mathematics in contrast with less than one quarter of the non-mathematics teachers. In addition, in comparing the results in Table 5.3 and Table 5.4, I noted that the non-mathematics teachers reported higher scores in liking of mathematics (68.7%) than all the other

Table 5.4: Percentage of reported liking of mathematics among teachers and students

Reported liking of mathematics	Teacher and student group			
	Mathematics teachers (n=29)	Other teachers (non-maths) (n=38)	Mathematics students (n=47)	Other students (non maths) (n=117)
Like	89.7%	68.4%	87.2%	36.8%
Unsure	0.0%	7.9%	8.5%	13.7%
Dislike	10.3%	23.7%	4.3%	49.6%

occupational groupings with the exception of the professional grouping (73.0%). In contrast, the non-mathematics students expressed the lowest liking of mathematics scores (36.8%) as compared with all the other occupational groupings. This is a matter of real concern, especially because the sample size of the non-mathematics student is moderately large (n=117). Although the generalisability of the result is limited due to the opportunity sampling employed in this study, this finding does give rise to concern as non-mathematics students constitute the overwhelming majority of students, and this group represents the future human resources of the nation. Moreover, these students are supposed to have benefited under the most recent innovations and improvements in education and yet the majority of them reported a disliking of mathematics.

I.5 Generalising the results

This study is based primarily on an opportunity sample, and despite *ad hoc* attempts to stratify it, the sample does not reflect the actual spread of occupational sectors in the population. There are doubtless several factors, which make the results ungeneralisable to the general public, such as the small sample size, the over-representation of some occupational groups, such as the professionals, and the under-representation of others, such as the unskilled workers. However, it is possible to address some of these limitations; and in particular, it is possible to adjust for the actual frequency of occupational groups in the population. Thus, to get a better picture of the predicted liking of mathematics in the population, I have modified the predicted liking of mathematics using the ratio of different Social Class based on occupation. This ratio was given in the 1991 Census Report for Great Britain (Office of Population Census and Survey, 1993). The result is shown in Table 5.5.

Table 5.5: Predicted liking and disliking of mathematics calculated based on proportion of occupational groupings of 1991 Census Report

Occupational grouping	Professional	Managerial & technical	Skilled	Unskilled & semi-s.	Others	Predicted result	Results in study (N=548)
*Percentage in population	3.59%	27.09%	43.44%	21.35%	4.53%	100.00%	
Reported liking of mathematics	73.0%	55.3%	43.2%	41.5%	49.7%[1] 37.1%[2]	47.29%[1] 46.72%[2]	53.8% 51.8%[1] 48.3%[2]
Reported dislike of mathematics	15.9%	30.9%	44.4%	40.0%	36.4%[1] 47.1%[2]	38.55%[1] 39.03%[2]	33.0% 34.3%[1] 37.3%[2]

Note: *Calculated from Table 91: Social class and economic position (10% sample) in Office of Population Census and Survey (1993).

[1] Result includes all students but excludes mathematics teachers (extrapolation based on sample size n=519).

[2] Result excludes mathematics students and mathematics teachers from the population (extrapolation based on sample size n=472).

Using the proportions of the population in the differing occupational groups in the 1991 census report, I extrapolate a score for the whole population on the assumption that the scores for each occupational grouping is representative. Using the results but excluding mathematics teachers for the same reason given earlier, I predict that about 47% of the public would express a liking of mathematics, irrespective of whether mathematics students are included or not. Thus the predicted result is slightly lower than my observed results of 48.3% (excluding mathematics students), and 51.8% (including mathematics students) and substantially lower than the result of 53.8% for the whole sample. In other words, the predicted liking of mathematics of the whole population, as expressed in response to my questionnaire, is about 47%, just slightly less than half.

The predicted response on dislike of mathematics is about 39% when mathematics teachers are excluded, irrespective of whether mathematics students are included or not. This is slightly higher than my observed results of reported dislike of 37.3% (excluding mathematics students and teachers) and higher than the results of 34.3%, with mathematics teachers excluded, and 33.0% for the whole sample. Extrapolating from these results leads to the prediction that almost two fifths of the population would express a dislike of mathematics. On this prediction almost as many people (only a difference of 8%) would express a dislike of mathematics (39%) as would express a liking of mathematics (47%). This is disappointing, especially as attitudes were more negative in the younger groups of the sample (excluding the oldest group). If, as my findings suggest, almost 40% of the population would express a dislike of mathematics, and this proportion is higher with younger persons, then there is a public attitude problem with mathematics in Britain that needs to be addressed. Of course, my extrapolation must be treated cautiously as there are no grounds for assuming that the scores by occupational groupings are fully representative.

I.6 Age group 17-20

As the young people group (17-20) is the group with the highest reported score for disliking mathematics, it is of interest to analyse the distribution according to the different subgroups of this age group. The sample of this age group is relatively small, consisting of 100 persons in total, comprising 23 mathematics students, 56 other students (non-mathematics), and 10 skilled, 8 unskilled and 3 unemployed young peoples. Since there are so few of them I have grouped these 21 respondents into a new category of ‘non-students’. Table 5.6 displays the results for this age group in terms of the distribution of reported liking and disliking mathematics among the three subgroups.

As shown in Table 5.6, there were observed differences between the three groups in terms of reported liking. The most striking feature is that the mathematics students have a dramatically higher reported liking of mathematics, with 82.6% expressing this preference. Even so, the fact that some of them express a dislike for mathematics, the subject they have chosen to study, is disappointing. These results contrasts with 30.4% and 23.8% expressed liking for the other two subgroups, results that are disappointing low in comparison with the rest of the sample, as well as with the extrapolated figures for the population. However, this drama tic difference is not surprising, perhaps given that mathematics students have chosen mathematics as their options for further study.

Table 5.6: Reported liking of mathematics among the young people between the age of 17 and 20 years old

Reported liking of mathematics	Subgroup of young people (17-20 years old)			
	Mathematics students (n=23)	Students: non-mathematics (n=56)	Non-students (n=21)	Total (n=100)
Like	82.6%	30.4%	23.8%	41.0%
Unsure	8.7%	14.3%	23.8%	15.0%
Dislike	8.7%	55.4%	52.4%	44.0%

Another interesting but disturbing feature is that slightly more than half of both the non-mathematics students and the non-students expressed a dislike of mathematics. Since these make up the overwhelming majority of school leavers, the fact that the majority of them express a dislike of mathematics is very worrying. Many of them will need to study or use mathematics and these prevalent attitudes are a very poor foundation for this. Furthermore, many will become parents of the next generation, and negative mathematical attitudes may be passed on in this way.

II. Expressed feelings towards learning mathematics

II.1 The whole sample

The respondents were asked to express their feelings towards mathematics when they thought of learning mathematics in school. They were given 14 items expressing different feelings to choose from. Seven of these represent positive feelings while the other seven represent negative feelings. Table 5.7 lists the 14 items of feelings given, and displays the sample's expressed feelings towards the learning of mathematics in school.

Table 5.7: Frequency distribution of expressed feeling towards learning mathematics of the whole sample

Positive feeling			Negative Feeling		
	Frequency	Percentage		Frequency	Percentage
interested	272	49.6%	Confused	202	36.9%
confidence	154	28.1%	Unsure	166	30.3%
enjoyable	125	22.8%	Worried	147	26.8%
happy	108	19.7%	Bored	132	24.1%
relaxed	68	12.4%	Nervous	102	18.6%
secure	59	10.8%	Threaten	90	16.4%
certain	43	7.8%	Cold	30	5.5%

Table 5.7 shows that about half of the sample (49.6%) expressed a feeling of being 'interested'. This is not surprising because this result concurs with earlier finding of this study (see Section I.1) that the majority (53.8%) of the sample reported a liking of mathematics. However, one third of the sample indicated that they were 'confused' and around one quarter expressed feelings of being 'unsure', 'worried' or 'bored'. In addition, the data indicates that about one sixth of the sample claimed to feel 'nervous' and 'threatened'. These negative responses lead us to worry about the environment or atmosphere of learning experienced in mathematics classes, at least for this sample.

II.2 Between genders

Table 5.8 displays the percentage of expressed feeling towards the learning of mathematics between the sexes. It shows that there was no striking difference between the male and female respondents in all the items of expressed feelings except the feelings of unsure, worried, nervous and threatened. However, the females felt more unsure, worried, nervous and threatened compared to the males with regard to learning of mathematics in school.

Table 5.8: Expressed feelings towards learning mathematics between males and females

Positive feeling			Negative Feeling		
	Male (n=268)	Female (n=280)		Male (n=268)	Female (n=280)
Interested	48.9%	50.4%	Confused	33.6%	40.0%
Confidence	30.7%	25.7%	Unsure	25.0%	35.4%
Enjoyable	21.6%	23.9%	Worried	20.1%	33.2%
Happy	17.5%	21.8%	Bored	27.2%	21.1%
Relaxed	14.2%	10.7%	Nervous	14.2%	22.9%
Secure	11.6%	10.0%	Threaten	13.1%	19.6%
Certain	9.3%	6.4%	Cold	5.6%	5.4%

II.3 Among the different age groups

Comparing the different age groups, a similar trend was observed in that there was no striking difference in the different feelings except the feeling of 'bored'. There was a trend of the younger the age group, the stronger the feeling associated with 'boredom'. 38% of the young people group (aged 17-20) responded that they were or had been bored by mathematics, whereas only 15-16% of the other groups (over 30 years old) expressed this view. (Full results are given in Table D.1, Appendix D). Moreover, the young people group tended to show the highest percentage in other negative feelings such as 'unsure' and 'worried' than the other older age groups, except for 'confused' (slightly lower than the oldest age group of over 50). Likewise, the younger age group also show lower percentages scores on the predominant positive feelings such as 'interested'; 'confidence'; enjoyable' and 'happy'. Once again, the data give rise for concern that the young people group (17-20 years old) shows much more negative images of mathematics than the older age groups.

II.4 Among the different occupational groupings

Among the nine occupational groupings, the data show that the expressed feelings of mathematics teachers and mathematics students skewed more towards positive feelings such as being interested, confident and enjoyable. In contrast, the non-mathematics teachers' and non-mathematics students' expressed feelings skewed more towards negative feelings such as being confused, unsure and worried. Moreover, there was a trend of the higher the social class (by occupation), the more positive expressed feelings they have when they thought of learning mathematics in school. There was a higher percentage of the professional group expressed positive feelings than that of all the other occupational groupings.

In terms of negative feelings, however, there was no similar trend observed among the different social classes. Instead, more than one third of the professionals expressed feelings of being confused and this percentage was slightly higher than the percentage of the social class II (the managerial and technical) and the social class IV (the unskilled workers). Detailed results for the comparison among the different occupational groupings are given in Table D.2, Appendix D.

II.5 Overall feelings towards learning mathematics

Besides analysing individual expressed feelings, I also computed a total score for all the 14 items of feelings. Half of them are positive items and the other half are negative items. Each chosen positive item was scored as ‘1’ and each chosen negative item was scored as ‘-1’. The overall feeling was then computed by summing up all the 14 individual scores. As a result, a maximum score of ‘7’ indicates a very positive reported overall feeling while a minimum score of '-7' indicates a very negative reported overall feeling. A score of '0' indicates a neutral feeling. To gain a better picture of the expressed feelings of the sample, I divided them into five categories using the range of scores as displayed in Table 5.9.

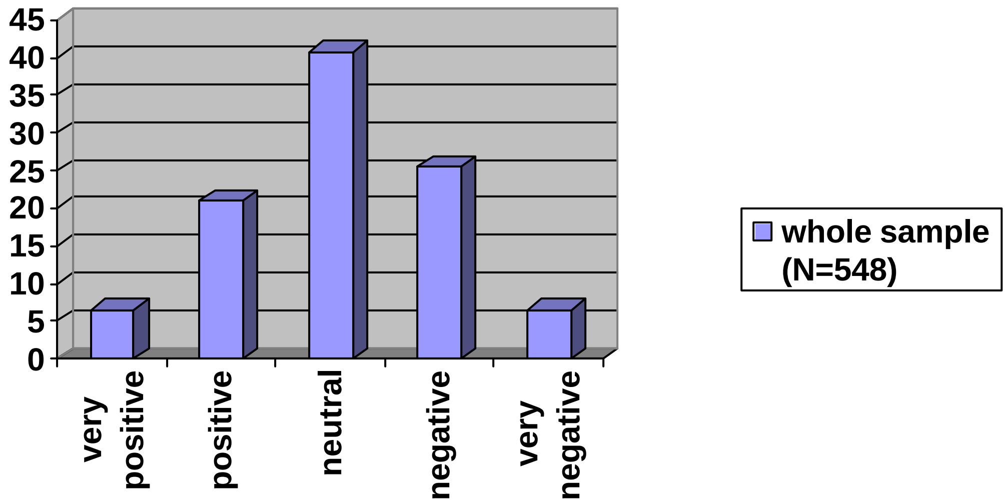
Table 5.9: Categories of overall feelings and range of scores

	Categories of overall feelings				
	Very positive	Positive	Neutral	Negative	Very negative
Range of scores	5 to 7	2 to 4	-1 to 1	-4 to -2	-7 to -5

Testing the reliability of this construct, 'overall feeling', I obtained a Cronbach alpha coefficient of 0.7843. Thus the 14 items are regarded as internally reliable (following the guidelines of Bryman and Cramer, 1997).

II.6 Frequency distribution of overall feeling categories

II.6.1 Whole sample



Based on the five categories, Figure 5.1 displays the frequency distribution of overall feelings for the whole sample. It indicates a normal distribution. 6% of the sample expressed either very positive or very negative overall feelings. About 40% of the sample show neutral overall feelings. However, the total number of respondents expressing negative overall feelings is 5% greater than that of expressing overall positive feelings.

II.6.2 Between males and females

As displayed in Figure 5.2, there were some observed differences between men and women on their total scores of overall expressed feelings. About 14% more women expressed negative overall feelings towards the learning of mathematics than their counterparts. Even though nearly equal proportion of men and women expressed positive overall feelings, there was a higher percentage of men expressed neutral feeling than women did.

One interesting observation is that men and women did not show much difference in terms of reported liking or disliking of mathematics, but women expressed more negative feelings towards the learning of mathematics in school than men did. The result suggests that there might be a gender difference in the experiences of learning mathematics in school, whereby the women tended to experience mathematics anxiety such as the feelings of unsure, worried and nervous. However, this remains speculative without further evidence.

II.6.3 Among different age groups

Comparing the different age groups, there was no major difference in the distribution of overall feeling category among all the age groups. However, the young people group (aged 17-20) expressed the highest in total percentages of negative feelings (7% higher than all the other age groups). This result seems to support the findings in the earlier section (see Section I.2) that, the young people group exhibited the highest percentage in disliking mathematics. Full results of this subsection are given in Table D.5 in Appendix D.

II.6.4 Among different occupational groupings

In terms of occupational grouping, the mathematics teachers and students skewed more towards positive feelings while the non-mathematics teachers and students skewed towards negative feelings. Among the other occupational groupings, there is an apparent general trend of increasing negative feelings from the professionals to the unskilled occupational groupings, similar to the results of reported liking of mathematics, reported earlier in Section I.3. Full results of this subsection are given in Table D.6, Appendix D.

II.7. Relationship between the overall feelings score and the reported liking of mathematics

The 'reported liking of mathematics' and the 'overall feelings score' (as defined in this study) were two constructs measuring similar aspects of the affective domain, so I was interested to investigate whether there was any correlation between them. As these variables were ordinal, I chose to use a non-parametric rank correlation analysis, namely the Spearman's rho test (Bryman and Cramer, 1997). The result shows that there was a significant correlation at the 0.01 level with a moderately high correlation coefficient of 0.605. This implies that those who claimed to like mathematics were often those who had positive feelings towards mathematics. The coefficient was, however, only moderately high, implying that there were some respondents who claimed to like mathematics but did not have positive feelings towards mathematics and vice versa. This leads me to inquire into who were this group of respondents who showed disparity in feelings and attitudes.

Using the same categorical grouping as the previous section, I made a comparison between two groups, those who reported liking and those who reported a disliking of mathematics. Figure 5.3 displays that 45% of those who reported a liking of

mathematics expressed positive (or very positive) feelings towards learning mathematics, whereas 60% of those who reported a dislike of mathematics expressed negative (or very negative) feelings. In addition, there were more than 12% of those who claimed to like mathematics but expressed negative feelings towards the learning of mathematics. This is interesting, as one would expect that those who claimed to like mathematics will most likely to express positive feeling, while those who claimed to dislike mathematics to express negative feeling. However, this linear relationship of reported liking of mathematics and expressed feelings towards learning mathematics might not be always so. Some people could have changed their attitudes towards mathematics after they left school. If this is so, then the results suggest that people could have positive attitudes towards mathematics even though they might have experienced negative feelings when they were learning mathematics in school. Likewise, people could have positive experience of learning mathematics in school, but yet develop a dislike of mathematics.

Another explanation is the unreliability of self-report attitudes questionnaire. What people state re their attitudes may not reflect their underlying dispositions consistently. Thus different modes of testing may reveal different aspects of their attitudes.

II.7.1 The discrepant groups

Here, I refer the 'discrepant group' to those who reported a liking of mathematics but expressed a very negative or negative overall feeling. I am interested to investigate whether there is any difference in their distribution in terms of gender, age and occupational groupings. Full results of the analysis of this subsection are presented in Tables D8-10, Appendix D.

In brief, some interesting findings were observed. There were 3% more female respondents than male respondents in the discrepant group. Among the different age groups, the middle age group (between 31 and 50 years old) were the majority (10.1%) in the discrepancy group whereas the young age group (between 21-30 years old) the least (2.9%). These results indicate that in spite of experiencing negative feelings in learning mathematics in school, some of the older respondents still exhibited positive attitudes towards mathematics. However, this phenomenon was found less commonly in the younger respondents.

Among the different occupational groups, the non-mathematics teachers (18.4%) showed the highest in this discrepancy, followed by the unskilled workers (10.8%). No mathematics teacher exhibited this discrepancy while the managerial (3.5%) and the non-mathematics students (3.4%) showed the least discrepancy. This finding leads me to speculate that even though these groups of people (in my study) might have negative experiences of learning mathematics in school, their attitudes towards mathematics could have changed. This might be due to the need to apply mathematical ideas in their careers, or because they have become more mature in their own thinking. Another argument could be that the negative feelings experienced by some of them might not have deterred them from liking mathematics. However, these explanations are merely speculations without further evidence to support. Therefore, in stage two of this study, I try to uncover some of the possible explanations regarding this phenomenon by interviewing some of these respondents who fall into this discrepant group.

III. Images of mathematics and learning mathematics

In this subsection, I shall first give an overview of the responses to the two open-ended questions (see Table 5.10), which asked the respondents to describe their images of mathematics and learning mathematics.

Table 5.10: Open-ended question on images of mathematics and learning mathematics.

III. 1 Overview of the responses

As expected, these two open-ended questions elicited a wide variety of responses. These responses were not only varied in range, but also reflected the variety of interpretations of the two key words, 'mathematics' and 'image' in this question. As I have discussed earlier in Chapter 3, the word 'mathematics' appears to be ambiguous to the respondents. It was found to refer to a number of different things including 'school mathematics', 'everyday mathematics' and 'academic mathematics'. Likewise, the word 'image' was interpreted in a variety of ways by different respondents. As I have discussed in Chapter 3, I have opted to define the term 'image of mathematics' broadly to include attitudes or feelings, beliefs, mental pictures as well as any verbal representations. However, I was surprised that the majority of the responses given reflect people's feeling and attitudes towards mathematics, rather than being in the form of mental pictures or verbal representations. This is interesting because the results suggest that the word 'mathematics' has triggered more of an affective reaction towards mathematics than a mental image of this other sort for most people. Implicitly this might suggest the close link between mathematics and mathematics learning experiences, because of the strong affective responses often associated with the latter. I acknowledge that I have had struggled the most in the analysis of the responses to these questions. However, I have managed to make some order out of them as reported below.

All the responses given were textual. As I had justified earlier in Chapter 4, I opted to analyse these responses qualitatively by categorisation. All categories were descriptive rather than prescriptive. They were all grounded in and derived from the data. Five main categories emerged from the analysis. They are (a) attitudes towards mathematics and its learning; (b) beliefs about the respondent's own mathematical ability; (c) descriptions of the process of learning mathematics; (d) views of the nature of mathematics; and (e) values and goals in mathematics education. Figures 5.4 and 5.5 show the frequency distribution of responses corresponding to the categories or subcategories for the images of mathematics and images of learning mathematics for the whole sample.

First of all, I found that most respondents gave their images of mathematics either in the form of propositions expressing feelings or views about mathematics (about 67%) or in the form of metaphors (about 27%). In contrast, images of learning mathematics were expressed more commonly in the form of metaphors (about 66%) than as propositions expressing feelings or views (about 19%). Thus, the result show that propositions are prevalent for the images of mathematics while metaphors are prevalent for the images of learning mathematics.

Secondly, many responses are made up of composite views and metaphors that can be interpreted in various ways. In order not to lose the richness and diversity of the data, I have coded the responses into multiple categories. For example, one response given was, learning mathematics is like "learning a new language - lots of signs and symbols - hard to use successfully at first" (Responses (R) 212). I coded this response to three entries: as 'language', 'numbers and symbols' and 'difficult'. Therefore, in total, there are

797 (727) entries corresponding to the categories for the image of mathematics (image of learning mathematics, respectively), for the 548 respondents in the total sample.

Thirdly, analysis of this data shows that there are many overlaps and similarities in the expressed images of mathematics and learning mathematics. Therefore, I decided to classify both types of responses using the same categories. This allows a direct comparison between images of mathematics and images of learning mathematics to be made later.

In the following subsections, I will first describe and discuss the responses to the images of mathematics and then follow this with the responses to the images of learning mathematics. As I aim to look for general patterns and to explore any possible range of common themes, I shall first describe each category, and report only the most striking subcategories with examples. I only report here those subcategories that have a frequency of response of more than 8 (or about 1%) of the total responses. In addition, I look into the frequency distribution to see how widely a particular subcategory of image is shared by members of the subsample, in terms of their gender, age grouping and occupational grouping. Only results that are relatively striking will be reported. Finally, I make a comparison between the categories of image of mathematics and that of learning mathematics, in terms of whole sample as well as by gender, age and occupational groupings. The full lists of categories and subcategories with verbatim example of responses are given in Appendix E.

Images of mathematics (F=797)

Attitude (feelings) (f=346 or 43.4%)	*Beliefs* (about own mathematical ability) (f=39 or 4.9%)	*Process of learning* (teaching/learning) (f=110 or 13.8%)	*Nature of mathematics* (f=237 or 29.7%)	*Values/goals* (in mathematics/education) (f=65 or 8.2%)
difficult(f=70) boring (f=58) anxiety(f=44) enjoyable(f=38) necessary/important (f=40) interesting (f=35) useful(f=21) exciting (f=18) rewarding (f=10) irrelevant (f=9) easy (f=3)	confusion(f=20) incomprehensible(f=12) difficult but possible(f=4) inability(f=3)	logical thinking(f=22) mental work(f=20) problem solving(f=18) hard work(f=14) effortful endeavour(f=11) repetitive process(f=8) getting difficult(f=4) skill(f=3) hierarchical(f=3) exploration(f=3) discovery(f=3) organising(f=1)	numbers and symbols(f=46) practical tools(f=25) formulae, equation/algebra(f=25) patterns/structure(f=20) complexity(f=19) a discipline/subject(f=26) games/puzzles(f=14) visual representations/geometry(f=12) rules and procedures(f=19) theoretical(f=8) a model(f=7) a language(f=5) exactness and precision(f=5) abstraction(f=5) proofs(f=1)	challenge(f=26) beauty of maths(f=20) objective(f=6) mystery(f=4) strange/foreign(f=3) orderly and tidiness(f=3) not creative/ imaginative(f=2) dangerous but attractive(f=1)

Frequency (f) = number of responses corresponding to the categories or subcategories.

Figure 5.4: Categories and subcategories of images of mathematics and frequency of corresponding responses

Images of learning mathematics (F=727)

Attitude (feelings) (f=272 or 37.4%)	*Beliefs* (about own mathematical ability) (f=62 or 8.5%)	*Process of learning* (teaching/learning) (f=227 or 31.2%)	*Nature of mathematics* (f=93 or 12.8%)	*Values/goal* (in mathematics/education) (f=73 or 10.1%)
anxiety(f=87) boring (f=38) enjoyable(f=27) necessary/important (f=24) difficult(f=24) uncertain/conditional (f=17) exciting (f=15) rewarding (f=12) interesting (f=11) irrelevant (f=7) easy (f=6) useful(f=4)	difficult but possible(f=21) confusion(f=13) difficult but rewarding (f=11) inability(f=10) incomprehensible(f=7)	problem solving(f=32) skill(f=30) exploration(f=20) hard work(f=19) slow and pointless(f=19) discovery(f=16) repetitive process(f=15) mental work(f=14) getting easier(f=14) hierarchical(f=13) effortful endeavour(f=12) logical thinking(f=7) getting difficult(f=5) memorisation(f=4) investigation(f=4) organising(f=3)	games/puzzles(f=33) a language(f=12) patterns/structure(f=10) numbers and symbols(f=6) rules and procedures(f=7) practical tools(f=6) a discipline/subject(f=8) formulae, equation/algebra(f=3) a model(f=2) complexity(f=2) theoretical(f=2) exactness and precision(f=1) visual representations /geometry(f=1)	mystery(f=24) strange/foreign(f=21) challenge(f=13) beauty of maths(f=5) objective(f=5) dangerous but attractive(f=3) orderly and tidiness(f=2)

frequency (f)= number of responses corresponding to the categories or subcategories

Figure 5.5: Categories and subcategories of images of learning mathematics and frequency of corresponding responses

III.2 Images of mathematics

III.2.1 Category (1) Attitudes towards mathematics and its learning

The result shows that 43% of the total respondents expressed their images of mathematics in the form of descriptions of attitudes, feelings or emotions that they had when they thought of mathematics or which the questions reminded them of. These images range from expressions of positive attitude such as "mathematics is fun and exciting" (R170) to expression of negative attitude such as "mathematics is dull, boring complex" (R182). Some emphasise the importance of mathematics such as "mathematics is important for everything" (R175) while others see mathematics as "irrelevant" (R053) or "a lot of things which I will never use" (R059). Descriptive statements, both positive and negative, including "mathematics is difficult" (frequency (f)=70), "mathematics is boring"(f=58), "mathematics is interesting"(f=53) are the three most common responses in this category. Metaphors which show positive images such as "mathematics is like playing with my children, never tiresome" (R526) or negative images such as "like eating nails - hard and painful" (R111) are also commonly expressed.

Ten subcategories have emerged from this category and detailed discussion for the most significant subcategories is as follows:

1a) **Difficult –** this subcategory is made up of all responses that indicate that mathematics is a kind of subject that is, 'difficult' or 'hard' to learn. The word 'difficult' appears in 39 out of 70 responses of this subcategory. Many responses were made up of composite views such as maths is "interesting but difficult" (R329) or "extremely difficult but very useful" (R374). There was also conditional view such as maths is "hard but enjoyable if I get it right" (R486). Metaphors, such as maths is "hard & solid, like a wooden square" or "melted chocolate - difficult to chew" that imply mathematics is something difficult to work with, were also common in this subcategory.

Comparing between gender, it is interesting to find that equal number of male and female respondents (f=13%) have 'difficulty' as central to their image of mathematics. However, in terms of occupational groupings, the skilled workers' (17.3%) and the unskilled workers' (15.4%) responses were top in this subcategory. Perhaps this is not a surprise because these subgroups presumably have lower mathematics qualification than the other higher social classes by occupation. Nevertheless, it is rather a surprise to notice that both the mathematics students and professionals also viewed mathematics as 'difficult' (both 15%) and their percentages were a little higher than the non-mathematics students were (f=12.8%). No mathematics teacher's response fell into this subcategory.

Looking at the responses in terms of age groupings, there were some interesting differences. While 19.0% of the young people group viewed mathematics as difficult, only 7.7% of the older group reported the same view. It is perhaps not surprising that 18.2% of those who reported a disliking of mathematics also viewed mathematics as difficult, however, it is perhaps more surprising that about 6.8% of those who reported a liking of mathematics also found mathematics difficult. This suggests that difficulty is widely associated with mathematics, whether or not respondents express a liking of the subject. Even some of them whose specialised subject is mathematics, for examples, the mathematics students and those who has higher degrees in mathematics qualification such as the professionals too, find mathematics difficult.

1b) **Boring** - this sub-category includes all responses that indicate feelings of boredom. The word 'boring' appears in 43 out of 58 entries of this sub-category. This sub-category also includes responses that contain wordings such as 'dusty', 'dry', 'dull' or 'not exciting'. Compared to the subcategory of 'difficult', this subcategory has fewer responses that indicate composite views. Most responses tend to indicate negative attitudes, such as maths is "dreadful, boring" (R079) or "boring and tedious" (R371). Very few responses under this subcategory were given in the form of metaphor.

It is interesting to notice that more responses that fit into this sub-category were given by male (12.3%) than female respondents (8.9%). In terms of age groupings, the 'boring' responses were most commonly given by the young people age group of aged between 17-20 years old (17.0%) and the young age group of aged between 21-30 years old (16.4%). This result reconfirm the earlier finding on expressed feelings towards learning mathematics (see section II. 3) that strikingly higher percentage of the young people group (aged 17-20 years old) expressed that they were or had been bored by mathematics than all the other age groups.

1c) **Anxiety** towards mathematics: mathematics is related to negative feelings, painful experiences or unpleasant emotions. Some examples of responses are maths is "a nightmare" (R185); maths is "painful, like your head bouncing on the wall" (R101); maths is "a sinking feeling in the stomach" (R479) or maths is "panic attack" (R213) and "frightening" (R355).

Out of the total entries of 796, there are 44 responses correspond to this subcategory. In contrast to the subcategory of 'boring', more female respondents (9.6%) than male respondents (6.3%) indicate responses that fit into this subcategory. Likewise, this result can be related to my earlier findings on expressed feelings towards learning of mathematics (see section II.2) that noticeably more females expressed feelings of anxiety such as 'unsure', 'nervous' and 'worried' than their counterparts. In addition, the non-mathematics students (10.3%) and the skilled workers (11.1%) are the most anxious subgroups

1d) **Enjoyable:** this subcategory includes all responses indicating that mathematics is 'enjoyable' or 'fun'. There are 14 out of 38 entries in this subcategory that gave single word answers 'fun' or 'enjoyable'. However, many of them show mixed feelings or composite views such as maths "can be fun but also a problem" (R542) or maths is "necessary to all in a limited form - a vocation to some" (R466). Perhaps it was not surprising to notice that the mathematics teachers (20.7%) and those reported a liking of mathematics top the list of those who has image of mathematics as enjoyable.

1e) **Necessary** or **important** refer to responses that indicate that mathematics is necessary, essential or important. Out of the 40 entries of this subcategory, some of them indicate strong feeling of importance or practicality of mathematics, such as "mathematics is important for everything "(175) or "mathematics is an essential tool for everyday life" (R128). But other responses tend to show mixed feelings or a composite view such as maths is "difficult but important" (R112) or "like going to see the doctor-horrible but sometimes necessary" (R208).

There were more male respondents (8.6%) than female respondents (6.1%) dominate the responses of this subcategory. In terms of occupational grouping, the managerial and technical group (12.9%) tops the responses in this subcategory, followed by the mathematics teachers (10.3%). Surprisingly, no mathematics student gave responses that indicate mathematics is important or necessary while there were at least 7.7% of the non-mathematics students believed so. Among the different age groupings, the older group (14.1%) seems to view mathematics as important and necessary more than the other age groups. The least responses were given from the young people subgroup (aged 17-20), only 4%.

1f) **Interesting –** this subcategory includes all responses that indicate mathematics as 'interesting', and the word 'interesting' appears in all the 35 entries. Perhaps, this is not a surprise as we recall the high percentage of reported liking for the whole sample (53.8% see Section I.1) and the high percentage of expressed positive feeling of 'interested' (49.6% see Section II.1). Composite views such as, maths is "interesting but at time boring" (R316) and metaphors such as, maths is "exciting and interesting, like new journey" (R500) were also grouped under this sub-category.

1g) **Useful -**This sub-category includes all responses, which indicate that mathematics is useful or practical. There were 21 responses correspond to this subcategory. Some examples are mathematics is "a useful analytical tool in daily life" (R441), "helpful when needed" (R272) or a "useful, intellectual pursuit" (R345). A few of the responses seem to indicate composite views such that, maths is "useful but often boring" (R066) or "extremely difficult but very useful" (R374).

1h) **Exciting—**At least 18 responses that indicate mathematics to certain degree of excitement such that, maths is "exciting" (R270), "excitement" (R321) and "exciting, elegance, creative" (R364) were included in this subcategory. There was only one composite response in this subcategory that view mathematics as both exciting (a positive attitude) but also a negative attitude such that, maths is "excitement and or frustration. It is my work so it is often in my mind "(R192).

1i) **Rewarding –** There were 10 responses in this subcategory and these responses indicate that maths is, a "challenging subject-intellectually satisfying" (R120) or "challenging journey-rewarded by arrival at your destination" (R255). Thus, it is closely related to something challenging or difficult, but it is also "satisfyingly difficult" (R099), although it could be "fulfilling" (R216) and "satisfaction" (R295) at the end.

1i) **Irrelevant -**In contrast to the above sub-category, this sub-category includes nine responses that indicate that maths is "irrelevant" (R053) or "not practical" (R059). Other examples are, maths is "a lot of thing which I will never use" (R492) or in the form of metaphor, maths is "like a water biscuit - dry and pointless - I never saw a use in much of what I was taught" (R285).

III.2.2 Category (2) Beliefs about own mathematical ability

In this sample, about 5% of the responses given reflect some kinds of beliefs about the respondents' own mathematical abilities. Some of them believe that mathematics is difficult but possible to achieve success such as mathematics is "like Mt. Everest, difficult to climb but not impossible" (R522); while others hold the opposite belief of inability such as "mathematics is difficult and [I] find hard to cope with" (R011). A number of them also found mathematics "incomprehensible" (R027) or "misleading and confusing" (R431). Five subcategories emerged from this category but only two of them are significant with more than 8 responses. These are:

2a) **Confusion -** All responses which contain the words 'confusing' or 'confused' or 'confusion' were grouped under this sub-category. There are 20 responses of this type and it is also the highest in frequency in this category. Most responses in this sub-category indicate some degrees of confusion such as mathematics is "puzzling" (R249) or mathematics is "logical at times, intangible and confusing (at) others" (R025). About half of the responses were given in the form of metaphors such as mathematics is "like alcohol, the more you consume the more confused you get" (R141) or maths is "really difficult and confused - like getting lost" (R397).

2b) **Incomprehensible -** this subcategory has 12 responses. All of them indicated that maths is "incomprehensible" (R027), "un-understandable, humiliating" (R440) or "hard and difficult to understand" (R094). A few responses also show certain degrees of accomplishment if they can understand mathematics, such that it will be "good if you [can] understand it" (R107) or "easy when you know how" (R327).

It is rather surprising to find that the mathematics students (6.4%) have the highest percentage of responses in this subcategory, even higher than those from all the other occupational groupings.

III.2.3 Category (3) Descriptions of the process of learning mathematics

About 14% of the total responses related images of mathematics in term of process of learning mathematics. Maths is viewed as**:** "*a skill* you need to learn" (R209); "*problem solving*, explaining physical processes" (R113); or as "voyage of *discoveries*" (R116); and as an *exploration*, such as maths is "like the arctic-unattractive but adventurous" (R108).

Many of the respondents indicated that mathematics is a *hierarchical* process like "a seven course meal, one theory lead to another" (R527); or involved *logical thinking* such as "logical stimulation" (R100) in nature and related to *mental work* such as mathematics is "a subject to test the mind" (R468). Mathematics is also viewed as a process of "*hard work***"** (R034) (and there were 14 responses given contained only these two words); or *effortful endeavour* as "something required concentration-satisfy when (it is) right" (R090); a *repetitive process* such as mathematics is "repetitive, structures and logical" (R105). Mathematics is also viewed as a process that is *getting difficult* as you go deeper or study more about it. Two metaphors corresponding to this subcategory are: maths is "like a peach-soft on edges but at the core hard like a stone" (R136); or an "abstract art - interesting but difficult and looking at it too long gives you a headache" (R300).

Among these eleven subcategories, logical thinking (frequency (f)=22), mental work (f=20) and problem solving (f=18) are the three subcategories with the highest corresponding entries. It thus implies that for those respondents, who view mathematics as related to its process of learning, mathematics is taken more as a cognitive process that involves logical and analytical thinking in order to solve a mathematical problem.

3a) **Logical thinking** - this subcategory includes 22 responses that relating mathematics to "logic, proofs and explanations" (R160) or "logical system applied in various areas of life " (R337) or "symbols, logic and patterns" (R390). These responses also indicate that maths is, "very logical" (R257), "analytical" (R056) and also could be "fun and rational" (R547). This view seems to be most prominent among the young people group (7.0%).

3b) **Mental work** - 20 responses were found in this subcategory. These responses relating mathematics to works that involve the brain such as "something challenging and stretching your brain" (R046) or " a brain teaser - a puzzle to be solved" (R388), or the mind as, "a subject to test the mind" (R468) or a kind of mental work. Many of them also found maths as a "stimulation to the brain" (R392), a "useful, intellectual pursuit" (R345) that is "interesting, stimulating " (R298) and "good for the brain" (R020).

3c) **Problem solving** – At least 18 responses in this subcategory indicating that mathematics is viewed a process of problem solving. Maths is "problem solving with numbers" (R452) or "calculation and solving of problems" (R448). Many of them also related this problem solving aspect to "a puzzles – you put the pieces together to get the whole picture" (R142) and it could be "fun when everything works out but remain a challenge" (R470).

III.2.4 Category (4) The nature of mathematics

Besides expressing as attitudes and feelings, many respondents' images of mathematics refer mathematics to the nature of mathematics. 29.7% of the total responses correspond to this category, making it the second most prominent category of the images of mathematics. The responses correspond to this category were made up of a wide variety of constructs that related to nature of mathematics. Mathematics is termed as 'humbers and equations" (R005); rules and procedures, pattern and structures. Mathematics is also viewed as a practical tool, a model, a language, a science or a discipline of study. 15 subcategories emerged but only 11 subcategories that have more than 10 responses will be discussed here.

4a) **Numbers and symbols** this subcategory is made up of all responses that refer mathematics as "numbers" (R030), "figures" (R473) or "algebraic symbols" (R001). The highest number of responses (f=46) occurs in this category. A few of these responses were made up of composite views such that mathematics is more than just numbers and symbols. For examples, maths is "symbols, logic and patterns" (R390), or "numbers and equation" (R050), or "the use of numerical analysis to solve problems" (R162).

About 7% more of those who reported liking of mathematics than those who reported disliking of mathematics viewed mathematics as numbers and symbols. Another obvious difference is many more young age groups and young students hold this image of mathematics as numbers and symbols than the older age groups and all the other occupational groupings.

4b) **Practical tools**- this subcategory has the second highest number of entries. It has 25 responses that indicate images of mathematics as related to some kind of practical tools, such as "a useful tool" (R196), a "banking account" (R494) or "dollars and abacus" (R224), that can help to solve daily life problems. Mathematics is also viewed as "a useful analytical tool in daily life " (R441) that could "helps me (to) see the £ ticking over" (R236) as well as a "human tool to calculate and predict" (R047) and "about helping scientists with their discoveries" (R161).

The responses of this subcategory are mostly given by the males (5% more than the females) and those who reported a liking of mathematics (also 5% more than the other subgroups). Perhaps it was not a surprise to notice that the professionals (9.5%) and the managerial and technical subgroups (8.2%) top the list because they would have to be those who found mathematics most practical in their careers.

4c) **Formulae, equation or algebra** - At least 25 entries correspond to this subcategory, which shows that images of mathematics are equated to "algebra" (R279) or "complicated equation" (R110). Similar to images of mathematics as numbers and symbols, most responses are also made up of composite views. Some examples are, maths is "numbers, algebraic equations, graphs" (R031) or "applied science – with extra hard sums " (R055). Many of the responses appear to relate to strong negative feelings such as "algebra! A nightmare!" (R538) or "lots of equations – tiring" (R283). The responses of this subcategory are prominently given by those who reported an uncertainty (6.9%) or a disliking of mathematics (6.1%). This finding lead me to speculate that for those who claimed to dislike mathematics, their images of mathematics might be characterised more by mathematics as equation and algebra than those who reported a liking of mathematics.

4d) **Pattern and structure** - this subcategory includes all responses that reflect image of mathematics as some kinds of patterns or structures. Maths is viewed as "pattern of numbers" (R013) or "repetitive, structures and logical " (R105). There are 20 entries grouped under this subcategory. It is interesting to note that most entries in this subcategory were presented in the form of metaphors such as mathematics is "a collage" (R286) or a "complex structure of wire" (R104).

4e) **Complexity –** this subcategory is made up of 19 responses that indicate that mathematics is related to something that is "complicated "(R188), or some kind of "complex structured building" (R119). Many of these responses also appear to link to strong negative feelings such that, maths is "dull – solving complex equation of little consequence" (R156) or "too complicated, obscure and not useful for my life except arithmetic for shopping "(R338).

4f) **A discipline or a subject of study** – At least 26 entries correspond to this subcategory. These responses relate mathematics to one or two topics in mathematics such as maths is "about statistics and hard" (R048) or "probability-yuk!"(R155). Some of them also viewed mathematics as "a complicated but interesting subject" (R360) or "a subject that required certain type of mind" (R415). Other (at least 10 respondents) viewed mathematics as a science. They gave images of mathematics as, "an exact science" (R190) or "a science - enabling us to measure physical and conceptual phenomenon" (R189).

4g) **Games or puzzles** - this subcategory is made up of 14 responses that viewed mathematics as a "good game, varied but logical" (R052) or a "maze" (R174) or "puzzles and problem solving" (R288). It is very interesting to notice that the females gave 13 out of these 14 responses.

4h) **Visual representation or geometry** - At least 12 responses in this subcategory indicating that some respondents relate their images of mathematics to some kind of visual representation such as "numbers, graphs, tables, logs" (R081) or geometry that include, "angles, lines, pyramids, shopping list etc "(R264). These visual representations seem to be rather appealing to some people because one respondent wrote that, maths "should be as wonderful as images through fractal geometry" (R478). However, to the others, these images might be boring and difficult to understand as another respondent gave her image of mathematics as "like a square root: square and boring" (R451) or "hard and solid like a wooden square" (R211).

4i) **Rules and procedures** - 19 respondents gave their images of mathematics relating to rules and procedures such that maths is "all about numbers and rules" (R049) or "rules, formulae learnt before understanding" (R109). This subcategory also includes images of mathematics as "calculation" (R044), "calculating" (R302) or "manipulation of numbers - a dry pastime" (R343).

4j) **Other subcategories** - A few of the respondents have their images of mathematics as theoretical, complex and abstract although they agreed that mathematics might also has the power of certainty, exactness and precision. One gave the metaphor that describes maths as, "abstract art-interesting but difficult & looking at it too long gives you a headache" (R300). Others viewed maths as "a way to model the physical world" (R301) or "the language of power" (R367). Thus mathematics is taken as a model, a language or that is related to "logic, proofs and explanations" (R160).

III.2.5 Category (5) Values and goals in mathematics and education

This category includes all responses that relate images of mathematics to the goals and values in mathematics or education. Eight subcategories emerged from the data but only two subcategories were made up of more than 8 responses.

5(a) **A challenge** - The most common subcategory was responses that indicated mathematics as a kind of challenge or a challenging activity such as maths is "challenging" (R487) or "a challenge" (R237). The word 'challenging' appears in 20 out of 26 responses of this subcategory. Others gave composite views such that maths is "fun when everything works out but remain a challenge" (R470) or maths is a "challenging subject-intellectually satisfying" (R120) or "a challenging journey – rewarded by arrival at your destination" (R255). These responses were mainly given by those who reported a liking of mathematics (7% more than those who reported a dislike of mathematics).

5(b) **Beauty of mathematics** - The second common subcategory contains 20 responses that show appreciation of the values in mathematics or the beauty of mathematics**.** Some respondents viewed mathematics as "clean and reliable" (R061), "powerful and beautiful" (R293) or "exciting, elegant and creative" (R364). Other expressed their images of mathematics as "like a sunset- unique and beautiful" (R168) or "like a blue sea – wide, calm, expansive knowledge and important" (R372). Out of the 20 responses in this subcategory, 18 were given by those who reported a liking of mathematics and none by those who reported a dislike of mathematics.

5(c) **Other subcategories** in this category also display maths as something objective such that, maths is "scientific, non-emotionally" (R147) or "fun and (has a) definite answer to work to". There were four responses that indicate mathematics as having some elements of mystery or mathematics is mysterious or unknown in nature. Some examples are mathematics is "like a woman-full of intriguing mysteries" (R167) or mathematics is "like a magic trick-seemingly baffling but possible to watch out how it was done" (R398). It is interesting to note that most responses match into this subcategory of 'mystery' was given in the form of metaphors.

III.3 Images of learning mathematics

Most respondents (66.4%) gave their images of learning mathematics in the form of a metaphor or a simile. This result might have been influenced by the format of the question asked. The question asked for the images of learning mathematics was: "learning mathematics is like…". As commented by Alan and Shiu (1997), the word 'like' might have prompted the respondents to give their answers in the form of metaphors or similes rather than in the form of expression of views or opinions.

As discussed earlier, the same categories used above were used to classify the images of learning mathematics. The results are shown in Figure 5.5.

III.3.1 Category (1) attitudes towards learning of mathematics

Similar to the images of mathematics, this category has the highest number of entries, 272 or 37.4% of the total entries. This high percentage of entries indicates that the sample's images of learning mathematics were very much linked to their emotions, feelings and attitudes towards mathematics. These images range from expression of positive attitude such as learning mathematics is like "an easy stroll on a windy day" (R034) to expression of negative attitude such as learning mathematics is like "a nightmare" (R023). Some respondents' views emphases the importance and usefulness of mathematics while others refer their images of learning mathematics to their own self-efficacy such as learning mathematics is easy or difficult. There were a variety of responses and 12 subcategories emerged from this category. Detailed discussion for the most significant subcategories is as follows:

1(a) **Anxiety** - this subcategory made up the highest numbers of entries (f=87) in the category of attitudes. It includes all responses that expressed negative feelings, painful experiences or unpleasant emotions. These responses also include expressions that indicated strong negative feelings such as, 'struggling', 'painful', 'frightening', 'unpleasant' and 'cold'. It is interesting to notice that all except one response were given in the form of metaphors. Examples are learning mathematics is like "walking through mud" (R155), "having a tooth pulled out" (R078), a "medieval torture" (R188) or "eating a bowl of stale corn flakes on a cold, grey morning" (R064).

Responses in this subcategory were dominantly given by those who expressed a dislike of mathematics (33.2%) than those who reported a liking of mathematics (6.1%). In terms of age groups, the young people group (22.0%) tops the list but the middle age group was the lowest (9.1%). Similar to the images of mathematics, the non-mathematics students (23.9%) and the non-mathematics teachers (23.7%) seem to show much more anxiety than all the other occupational groupings. Once again, this result implies that the young people and the non-mathematics students seem to associate much more anxiety than all the other subgroups in both of their images of mathematics and learning mathematics.

1(b) **boring** - Relatively high frequency of responses (f=38) correspond to this subcategory indicates that learning mathematics is related to some degree of boredom. Learning mathematics is, "boring" (R014), "boring basically" (R416) or "get very bored" (R528). It is interesting to notice that a few of the respondents used the same kind of metaphors to describe their images of learning mathematics, including learning mathematics is like "going to sleep" (f=4) or learning mathematics is like "watching paint dry" (f=9). Besides these two common metaphors given, other metaphors are learning mathematics is like "family do's - boring, repetitive and long winded" (R106), or "a boring recipe - not related to real world" (R499).

Similar to the images of mathematics, there were more male (8.6%) than female (5.4%) respondents who associated their images of learning mathematics to boredom. Likewise, the young people group (12.0%) and the unskilled workers (13.9%) gave the greatest proportion of this type of response.

1(c) **Enjoyable** - In contrast to the subcategory of 'boring', 27 responses correspond to this subcategory that indicates learning mathematics is enjoyable or fun. It is interesting to find that the majority of these responses were given in the form of metaphors such as, learning mathematics is like "watching TV, never want to turn off" (R526), "eating chocolate spread, yummy yummy " (R305) or "a cold shower - refreshing" (R061).

Unlike the subcategory of 'boring', there were three times more males (7.5%) than females (2.5%) gave the responses in this subcategory. The responses from the mathematics students (12.8%) and the professionals (7.9%) also top the list.

1 (d) **Necessary/important** - This subcategory includes 24 responses that indicate that learning mathematics is important and necessary, something that "has to be done" (R414). It is just like "doing one's duty" (465) or as important as "the lighting in a building" (R146). Some associate learning of mathematics to an essential skill such as, "learning to walk, we've all go to" (R009) or a process that is necessary to do such as, learning mathematics is like "life - getting on to bed" (R377).

On the other hand, there were also composite views that admit the necessity of mathematics but arouse negative feeling towards it. Examples of these responses are: learning mathematics is like "house work - boring but necessary" (R058) or "eating Brussels sprouts - forced to digest them because they are good for you even though nobody like them" (R088).

1(e) **Difficult -** this subcategory includes 24 responses that indicate that learning mathematics is "difficult" (R057), "tough" (R320) even though it could be also "hard but fun" (R195). More than half of the responses were also given in the form of metaphor such that, learning mathematics is like "eating nails - hard and painful" (R111) or playing "rugby - hard but challenging" (R102).

1(f) **Uncertain or conditional** - This subcategory is made up of 17 responses that associate learning of mathematics to certain degree of uncertainty, such that learning mathematics is like "building a boat, at the end it either floats or sinks" (R165); or "learning a foreign language, sometimes easy sometimes hard" (R524). There were some responses that show conditional views such as, learning mathematics is like "a pleasant mental exercise - providing it is well taught in appropriate steps" (R475) or "could be very good if taught properly" (R399). Four responses given appear to emphasise the condition of 'being well taught' in their images of learning mathematics. Although this number is relatively too small to make much conclusive implication, it thus suggests the important role of mathematics teaching in some of the respondents' images of learning mathematics.

1(g) **Exciting** - Out of the 15 responses included in this subcategory, seven of them related their images of learning mathematics to watching magic shows, such as learning mathematics is like "watching a magic show - full of excitement and mysteries" (R342). Most responses in this subcategory were given in the form of metaphor such as, learning mathematics is like "an exciting tour of discovery" (R177) or "fair around ride - full of excitement" (R127).

1(h) **Rewarding -** 12 respondents claimed that learning mathematics is "rewarding" (R067) or providing "satisfaction" (R494) even though some acknowledged that it was also "challenging but often rewarding" (R197). This subcategory is also characterised by responses given in the form of metaphor, such as learning mathematics is like "solving a mystery, rewarding when it has been solved" (R540)) or "a bike ride - sometimes easy, sometimes challenging - always have real moment of satisfaction" (R052).

1(i) **Interesting** - This subcategory is made up of 11 responses that include the word "interesting" in their responses. These responses are either expression of positive attitudes, such as learning mathematics is "interesting" (R276) or in the form of metaphor such as, learning mathematics is like "eating a bigger lots of interesting teasers" (R255). There were four responses that expressed mixed feelings such that, learning mathematics is "interesting but difficult" (R529) or "interesting but hard work" (R327). At least two responses, which indicate positive feeling but with condition such as learning mathematics is "interesting if taught the right way" (R502) or "a pleasant mental exercise -providing it is well taught in appropriate steps" (R475).

III.3.2 Category (2) Beliefs about own mathematical ability

This category includes all responses that relate the respondents' images of learning mathematics to their own mathematical ability. Most responses were given in the form of metaphor such as, learning mathematics is like "running uphill - difficult but you get there" (R376) or "climbing a mountain - once you reached the top - very satisfying" (R126). These responses show that many of the respondents acknowledged that learning mathematics was difficult but they also believed that it was possible to achieve success and it would be rewarding at the end. Other responses indicate that the respondents were uncertain about their own mathematical abilities, such that "trying very hard to learn but it can't work - very hard, I can't do it" (R094). A few respondents believed that learning mathematics was "impossible" (R530) for them because learning mathematics is "like a confused incoherent nightmare" (R181). It was "very hard and not understandable" (R443). Other respondents expressed more intense negative feelings of confusion and frustration in learning mathematics, such that learning mathematics is like "wondering further and further into a maze - full of confusion and dead-ends" (R285). Five subcategories emerged in this category but detailed discussion for the four most significant subcategories only is as follows:

2(a): **difficult but possible** - This subcategory includes 21 responses that indicate the respondents' belief that it was possible to succeed in learning mathematics even though it might be difficult. Some interesting responses are learning mathematics is like "walking through sand-hard work but you put in effort you'll get there" (R136), "starting in the dark but seeing the light at then end of tunnel" (R237). Another interesting observation is that all responses in this subcategory were given in the form of metaphors and most of these metaphors tend to relate to certain kind of 'journey', 'hill' or 'mountain' climbing. The common metaphors are learning mathematics is like "climbing a rocky mountain" (R117), "climbing a steep hill" (R218) or "a journey through a dark tunnel with a light at the end" (R139).

2(b) **confusion -** there were 13 responses in this subcategory, which expressed intense negative beliefs about their own mathematical abilities. Learning mathematics is like "being in a hurricane-everything gets very confusing" (R142) or "groping through fog" (R412). These responses show confusion and frustration in learning mathematics. It is interesting to note that more than half of the total responses in this subcategory (f=13) were prominently given by the females (f=10).

2 (c) **difficult but rewarding** - Like the subcategory of 'difficult but possible', 11 responses in this subcategory indicate that learning mathematics is a difficult process but there is a feeling of reward and satisfaction at the end. For example, learning mathematics is like "climbing the mountain - worth the view" (R292) or "conquering an assault curse - hard but with practice, easier and satisfying" (R474). Perhaps, this feeling of rewarding or satisfied might have driven some of these respondents to continue learning mathematics, as one of the them viewed learning mathematics as like "succeeding or winning an athletic match - bloody hard at the time but amazing after" (R547). Another respondent found the sense of achievement, such that learning mathematics is like "hill walking - hard but worth the sense of achievement" (R300).

2(d): **inability** - Unlike the other subcategories, responses in this subcategory tend to be given as expression of view such as, learning mathematics is "impossible" (R530, rather than in the form of metaphors. Some respondents expressed the view that they lacked the ability to learn mathematics because it was "too much to take in and retain" (R036) or they had been "trying to learn but it can't work-very hard, I can't do it" (R094). A few others gave their images of learning of mathematics in the form of metaphors such as, learning mathematics is like "going down a black hole that you can't get out of" (R396). All the 10 responses included in this subcategory show intense negative images of learning mathematics. One interesting observation is that out of these 10 responses, nine of them were given by the female respondents.

III.3.3 Category (3) Descriptions of the process of learning mathematics

This category has the second highest frequency (31.2%) of entries. A number of the respondents gave their images of learning mathematics as "solving problems" (R089), learning a skill such as "learning to ride a bike" (R160). Some refer learning of mathematics as "exploring" (R531), "hard work" (R220) or " a discovery" (R210). Others view learning of mathematics as a slow and pointless process such as "watching paint dry" (R421). Similar to the images of mathematics, this category is made up of a wide variety of conceptions relating learning mathematics to processes of learning. 16 subcategories emerged in this category and detailed discussion for the 11 most significant subcategories are as follows:

3(a) Problem solving - this is the most prominent subcategory of this category with 32 corresponding entries. Many of these responses relate learning of mathematics to a process of solving problem or finding new way to complete a puzzle or maze. Some typical examples are learning mathematics is like "solving a mystery" (R295), "finding new way of solving problems" (R075) or in the form of metaphor such as, learning mathematics is like "unravelling a tangled ball of wool" (R211), "finding your way through the maze" (R174).

Surprisingly, only 2% to 3% of mathematics students and teachers held this view.

3(b) **A skill -** Closely related to the above subcategory 'problem solving', 30 responses in this subcategory refer learning mathematics to learning various kinds of practical skills that are essential for everyday life. Typical examples are learning mathematics is like "learning to walk, we've all got to" (R009), "gaining a practical skill" (R176) or "riding a bike - it needs practice" (R370). There is also an element of unforgettable skill in some of the responses such as learning mathematics is like "riding a bike-one learnt never forgotten" (R123), or "riding a horse - difficult at first but once got it, you don't forget" (R080). These responses indicate that learning mathematics is similar to any skill learning and it needs a lot of practice. However, once you have acquired the skill, you will never forget how to use it.

These responses were given more by those who reported a liking of mathematics than their counterparts. In addition, the young people subgroup seem to top the list with 7% more than the older subgroup (aged over 50 years old).

Comparing these two subcategories (3a and 3b), it might be interesting to note that the older subgroup who like learning of mathematics tend to view learning mathematics as a process of problem solving but the young people group tend to like mathematics because they viewed it as a practical skill.

3(c) **exploration** There were 20 responses that made up this subcategory, equating the learning of mathematics to "exploring" (R539), "an exploration into another world" (R113) or "being an explorer - finding new paths and worlds" (R364). It is interesting to notice that all the 20 responses in this subcategory came from respondents who expressed a liking of mathematics. Two times more males than females held this view. In terms of occupational groupings, the mathematics teachers (13.8%) and the mathematics students (10.6%) top the list. This result might lead me to speculate that one of the reasons for people to like mathematics might be because they experienced the learning of mathematics as a kind of exploration. Moreover, more males than females seem to hold this view of learning mathematics.

3(d) **Hard work -** Out of the 19 responses in this subcategory, there are 10 entries with two words 'hard work' as their answer. Others gave composite views such that learning mathematics is like, "hard work- mind baffling" (R063), "ploughing through a field - if you're lucky it works out" (R258) or "hard work - can be boring but some is interesting" (R161).

Interestingly, responses in this subcategory were prominently given by the older age group (7.7%) and the mathematics students (6.4%).

3(e) **Slow and pointless process -** In this subcategory, out of the 19 responses, there are 8 responses that use the same simile, learning mathematics is like 'watching paint dry' to describe their images of learning mathematics. None from these eight respondents reported a liking of mathematics. Another observation is that these responses seem to show an inherent element of 'time factor', indicating that learning mathematics is like "chewing gum, long-lasting" (R018) or "solving a complicated puzzle: there is an answer but it takes a long time to find it" (R361). These responses appear to indicate that learning mathematics is a very slow process that consumes a lot of time.

3(f) **Discovery -** Closely related to the subcategory 'exploration', this subcategory includes all responses that viewed learning mathematics as a way to discover something new or unknown. There is always an element of 'new' and 'mysterious' in most of the 16 responses included in this subcategory. Some interesting examples are learning mathematics is like "discovering new things-opening a box not knowing what is inside" (R147), "discovering a secret" (R286) or "opening a door and not knowing what is behind it" (R478).

The responses of this subcategory were dominantly given by those who reported a liking of mathematics (4% more than its counterpart) and not surprisingly, the mathematics teachers (6.9%) and the mathematics students (6.4%) top the list. However, almost equal percentage of male and female respondents shared the same view.

3(g) **Repetitive process** - The responses of this subcategory is characterised by metaphors indicating that learning mathematics is a long lasting and never-ending process of repetitions. Some typical examples are learning mathematics is like "walking on a moving walkway - it never stop " (R250) or " a never-ending marathon-you never get to the end" (R103). Subsequently, many of the responses also reflect feeling of boredom, such that learning mathematics is like "family do's - boring, repetitive and long winded" (R106).

3(h) **Mental work -** 14 Responses included in this subcategory and they tend to relate learning of mathematics to a mental process or a certain kind of mind work. Learning mathematics is like "training a particular part of brain" (R047), "a mental challenge" (R209), "organising the mind" (R480).

3(i) **Getting easier -** This subcategory also made up of 14 responses but they seem to show that learning of mathematics is a process that is getting easier as you learn more about it. Interestingly, all the responses in this subcategory were given in the form of metaphors. Some interesting examples are learning mathematics is like "a ladder, you feel confident as you grasp each rang or topic" (R534) or "an uphill walk-hard to get top but easy from there" (R082).

3(j) **Hierarchical -** This subcategory made up of 13 responses, includes all responses that indicate learning mathematics as a hierarchical or step by step process of learning. Some interesting examples are learning mathematics is like "brick laying-each brick is the foundation for the next block" (R081) or "climbing a mountain-you have to take it one step at a time, can't miss any steps" (R343).

3(k) **Effortful endeavour -** Closely related to the subcategory of 'hard work', this subcategory includes 12 responses that indicate learning mathematics as a process of learning that need full concentration and a lot of efforts. Learning mathematics is like "learning to ride a bike, takes plenty of practice" (R520), "being very focus and hard working" (R073) or "riding a bike, keep trying until you can do it" (R535). Therefore, it could be "tedious" (R302) at times.

Besides the above 11 subcategories which were made up of more than 10 responses each, learning mathematics is also viewed as related to memorisation of numbers, facts or rules, such as learning mathematics is like "trying to memorise a wall of numbers" (R108). Unlike the images of mathematics (f=22), there were only 7 responses that correspond to the image of learning mathematics as a kind of logical thinking. Learning mathematics is like "learning to think correctly and logically" (R384) or "exercise in pure logic (an exploration)" (R301) are two of the examples. There were also five responses that view learning of mathematics as a process that is getting more difficult as one learn more or go for higher mathematics. Two interesting metaphors are learning mathematics is like "steaming porridge - get tougher to move as you learn more" (R055) or "riding a bike - simple enough until you come to a mountain" (R066).

III.3.4 Category (4) The nature of mathematics

There is relatively low frequency of images of learning mathematics correspond to this category (f=12.8%). This is presumably logical from the view that image of learning of mathematics is more related to a process of learning whereas image of mathematics is to be viewed as an epistemology. However, some respondents seem to give similar responses to their images of mathematics and images of learning mathematics. Similar to my results on the images of mathematics, there were a wide variety of responses corresponding to this category, but the number of entries was relatively small in each of the 15 subcategories. The most prominent subcategory was the one which referred to the learning of mathematics as playing games or solving puzzles (f=33). The next two subcategories that have the frequency of more than 10 are learning mathematics as learning a language and learning mathematics as learning patterns or structures. All the remainder 12 subcategories are made less than 8 responses. Therefore only the three more prominent subcategories will be discussed in detail here.

4(a) **Games/puzzles** Responses in this subcategory equate learning mathematics to playing games or doing a jigsaw puzzle. Some typical examples in this subcategory are learning mathematics is like "playing a games" (R493), "doing a cross-word" (R537) or "putting together a 1000 pieces of jigsaw" (R330). Some respondents seemed to relate this activity to positive feelings such that, learning mathematics is like "playing tennis - very relaxing" (R100) but others relate it to negative experience, such that learning mathematics is like "trying to put together a jigsaw together with the wrong pieces" (R152). In terms of occupational grouping, the non-mathematics teachers (10.6%) and the mathematics students (10.5%) gave the greatest number of responses in this subcategory.

4(b) **A language** - In this subcategory, the 12 responses given were characterised by relating learning of mathematics to learning of a language. It is interesting to observe that these responses appear to link to elements of 'new', 'foreign' or 'different'. Typical examples are learning mathematics is like "learning a foreign language" (R277), "learning another language" (R326) or "speaking a language you don't know" (R518). Thus, these images of learning mathematics seem to indicate that there are elements of mystery and foreign inherent in mathematics, such that learning mathematics is like "learning a foreign language with no books, no teachers, no rules" (R440).

4(c) **Patterns or structures** There were 10 responses included in this subcategory and these responses tended to equate learning mathematics to learning patterns of number, such that learning mathematics is like "creating a design with numbers" (R150). Some responses indicate that learning mathematics is related to some kinds of structured and inflexible way of learning, such as learning mathematics is like "reading from a book-set structure and inflexible" (R128) or "a chain or building binds, one process leads to another, inevitably important " (R527).

4(d) **Other subcategories** Besides the above three subcategories, some respondents gave their images of learning mathematics related to learning of 'a discipline or a subject' (f=8), 'numbers and symbols' (f=6), 'rules and procedures' (f=7) or 'practical tools' (f=6). However, unlike the images of mathematics where there were 46 responses indicated that mathematics is numbers and symbols, only six respondents viewed learning mathematics as such. This is a major difference between the images of mathematics and the images of learning mathematics. This result suggests that for some respondents in this study, the way they view mathematics may be different from the way they view the learning of mathematics.

There were only one or two entries that indicated that learning mathematics is 'theoretical' (f=2); 'complexity' (f=2); involving 'equation or formulae' (f=3) and relating some visual representations (f=1). However, there is no response that corresponds to learning mathematics as a 'proof' or an 'abstraction'.

III.3.5 Category (5) Values or goals in mathematics education

This category is made up of about 10% of the total responses that relate the learning of mathematics to goals or values in mathematics and education. Seven subcategories emerged but the three most prominent subcategories are responses that indicating elements of 'mystery' (f=24), 'foreign or strangeness' (f=21) and relating mathematics as a 'challenge' (f=13). Other values in mathematics education that are reflected in this category are 'beauty of mathematics' (f=5), the 'objectivity' (f=5) of mathematics and learning mathematics is related to 'orderliness and tidiness' (f=2) Only the most prominent three subcategories are discussed below in detail.

5(a) **Mystery** - Unlike the images of mathematics, the element of 'mystery' seems to be more prevalent in many respondents" images of learning mathematics. Some interesting examples are learning mathematics is like "being on a mystery tour-you don't know what's around the next bend" (R366), "discovering new thing - opening a box not knowing what is inside" (R147) or "solving a mystery, rewarding when it has been solved" (R540).

Interestingly, these responses were prevalently given by those who reported a liking of mathematics (6.8%) as compared to those who reported a dislike of mathematics (1.1%). In terms of occupational groupings, both the mathematics teachers (10.3%) and non-mathematics teachers (10.5%) were at the top of the list. This result seem to suggest that those who reported liking and the teachers might be the ones who appreciate mathematics more by linking it to its mysterious nature of mathematics.

5(b) **Foreign or strangeness** - The element of 'strangeness' or 'foreign' is also common in over 21 responses of this subcategory. Many respondents related their images of learning mathematics to certain kind of strangeness such as, learning mathematics is like "floating in another world with different rules" (R135) or "going to a new country" (R392). Some gave composite views such as, learning mathematics is like "having a supernatural experience: if you see the light, it's fantastic otherwise it's a nightmare" (R426). This subcategory is also closely related to the above subcategory of viewing learning mathematics as learning a language. Typical examples are learning mathematics is like "learning a foreign language" (R277) or "learning a new language" (R216). These responses were prominently given by the young people group (7.0%) and the mathematics teachers (17.0%).

5(d) **A Challenge** - Unlike the images of mathematics (f=26), relatively fewer responses (f=13) correspond to this subcategory for the images of learning mathematics. Learning mathematics is viewed as "a challenge" (R148), "challenging" (291) or "a mental challenge" (R209). Some responses are made up of composite views such that, learning mathematics is like "rugby-hard but challenging"(R102) or "fun and challenging (but not when I was at school)"(R140). A few responses also imply learning mathematics as a challenging activity such as, learning mathematics is like "a competition" (R473) or "a battle" (R504). One interesting observation is that 12 out of the 13 responses in this subcategory were given by those who reported a liking of mathematics. No one from those who dislike mathematics gave their images of learning mathematics related to 'a challenge'. This result suggests that one of the differences between those reported a liking of and those who reported a dislike of mathematics is that, both groups might viewed learning mathematics as difficult but the former takes it as a challenge while the latter does not.

5(e) **Other subcategories** - In addition to the above three subcategories, there are four more subcategories that are made up of less than five responses. Five respondents gave their images of learning of mathematics reflecting appreciation of the beauty of mathematics, such as learning mathematics is like "enlightenment" (R438) or "sharing inner feelings"(R288). Interestingly, compared to the images of mathematics (f=20), this is far fewer and this might indicate another difference between images of mathematics and images of learning mathematics.

Other subcategories include responses that indicate learning mathematics to the learning of an objective knowledge, and there is always a right answer or right solution to a problem. Typical examples are learning mathematics is like "catching a train - sense of relief when you're sure you're on the right track" (R543) or like "science - discovering new ideas and finding them to be right" (R239).

III. 4 A comparison between the categories of the images of mathematics and that of learning mathematics

After describing and discussing the responses to each category and subcategory, I thought it would be interesting to compare the major categories of images of mathematics and that of learning mathematics. Hence, I have compared these categories in terms of (i) the whole sample; (ii) between those who reported liking and disliking of mathematics; (iii) between the different gender, age and occupational groupings.

III.4.1 The whole sample

As I have discussed earlier (see Chapter 4, section 4.6 and Table 4.5), in order not to lose the richness and diversity of the data, each response to image of mathematics (or learning mathematics) was coded into one to three categories or subcategories. As a result, there were a total of 797 (727) entries corresponding to the five major categories for the image of mathematics (image of learning mathematics, respectively). Figure 5.6 displays the frequency distribution of these entries that have fallen into each major category of image of mathematics and that of learning mathematics for the whole sample.

Figure 5.6 shows that more than a third of the total entries fall into the category of attitudes for both images of mathematics and that of learning mathematics. These results indicate that for many respondents in this study, their images of mathematics and learning mathematics seem to reflect their feelings and emotions, and attitudes towards mathematics and learning mathematics, much more than to the epistemological aspect of mathematics. Nevertheless, there were about 30% of the total entries for images of mathematics fell into the category of the nature of mathematics, while 31% of the total entries for images of learning mathematics were referred to the process of learning. Thus there are both similarities and differences in the way images of mathematics and that of learning mathematics were conceptualised by the sample of this study.

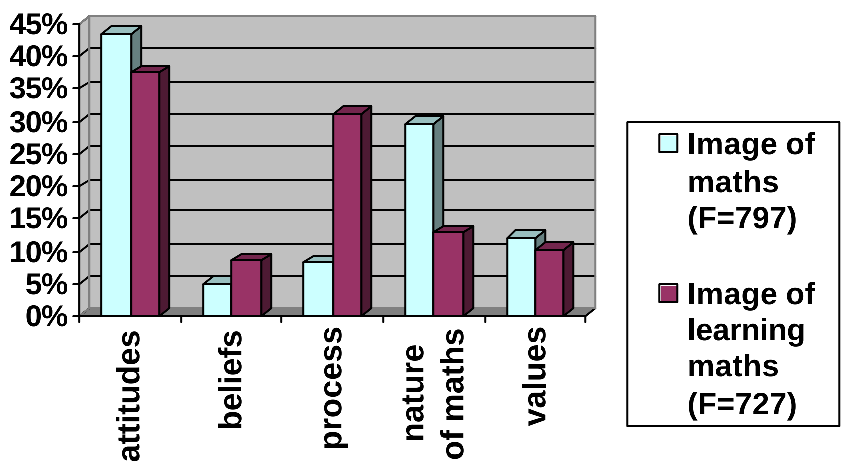


Figure 5.6: Frequency distribution of categories of images of mathematics and learning mathematics for the whole sample

III.4.2 A comparison between those who reported liking and disliking of mathematics

First of all, I chose to compare only those who reported liking mathematics and those who reported disliking mathematics and ignore those who reported uncertainty in liking mathematics. Secondly, I calculated the total entries of responses for each group and calculate the percentage for comparison based on these total entries. The results are displayed in Figures 5.7 and 5.8.

As displayed in Figure 5.7 and Figure 5.8, there were some striking differences between those who reported a liking and those who reported a dislike of mathematics on both their images of mathematics and that of learning mathematics. For those who reported a dislike of mathematics, the majority of their responses fell into the category of attitudes for images of mathematics (55%) and images of learning mathematics (54%). In contrast, for those who reported a liking of mathematics, only 37% of their images of mathematics and 30% of their images of learning mathematics fell into the category of attitudes.

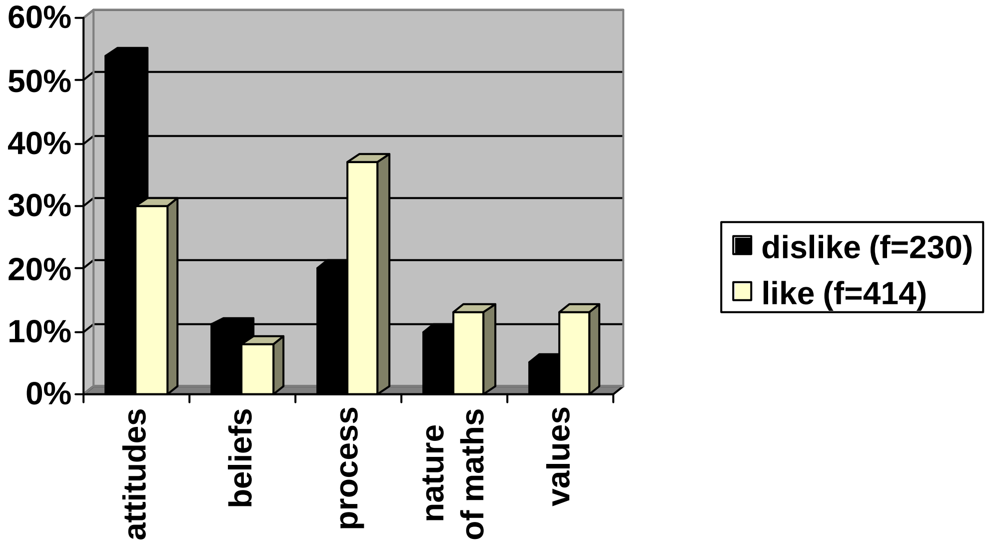


Figure 5.8: Distribution of categories of images of learning mathematics between those who reported liking and disliking mathematics

In addition, for those who claimed to like mathematics, about 8% more of their responses fell into the category of 'values in mathematics or education' than that of those who claimed to dislike mathematics. Conversely, there were 3-6% more of the responses given by those who reported a disliking of mathematics fell into the category of 'beliefs about their own abilities' than their counterparts. These findings are interesting because they suggest that the images of mathematics and learning mathematics might have some correlation to the reported liking and disliking of mathematics. In particular, for those who reported a disliking of mathematics, their images of mathematics and learning mathematics reflect an overwhelming emotion and negative feeling so much so that most of them tend not to see mathematics in terms of its values or epistemological aspect.

III.4.3 Comparison between gender, age and occupational groupings

When responses from the different subgroups were compared, there was no striking difference between gender and age group with regard to their images of mathematics and learning mathematics. In terms of occupational grouping, perhaps it was not a surprise to notice that the two dominant groups who presented their images of mathematics and learning mathematics in terms of values in mathematics or education were mathematics teachers and mathematics students. Likewise, the professional and the managerial subgroups tended to link their images of mathematics to values in mathematics or education, slightly more than the other occupational subgroups.

IV. Espoused beliefs about mathematical ability and gender differences in mathematical ability

IV.1 The whole sample

With regard to the belief about mathematical ability, the majority of the sample (95.4%) agreed that some people are better in mathematics than the others. For those respondents who espoused belief in mathematical ability, they were given four possible contributing factors, and were asked to rank them in an order of increased importance.

When analysing the responses, I encountered two problems. Firstly, there were two respondents who just marked up all the four factors without ranking them. Initially, I resolved this problem by coding all the choices as equally important or as the most important. However, I discarded then later because they did not serve to indicate any ranking of importance. Secondly, some respondents only ranked one or two of the factors given. As a result, some factors, such as 'home environment' has a percentage of 'no response' as high as 41.2%. Indirectly, the percentage of no response indicates that these factors were not chosen by the respondents as important. Thus, I assumed that the higher the percentage of no response, the less important is the factor of importance. So, I thought of choosing only those who rank all four factors in order, but then I will lose some responses that indicate certain factors to be very important. In the end, I decided to use the most important factor identified by the respondents to indicate their attributions of mathematical ability. However, I acknowledge that as a result of the problems mentioned above, some factors will have higher loading than the others. To obtain a standardised score for each factor, I calculated the percentage of importance for each factor based on the total scores of the most important factor chosen for all the four factors. Table 5.11 displays the results of the frequency and percentage of the factor chosen.

Consequently, the result shows that slightly less than half of the sample (48.6%) chose ‘inherited mathematics ability’ as the most important attribute. The second attribute chosen was ‘mathematics teachers’ (25.2%) followed by ‘effort and perseverance’ (19.7%). This is interesting because the results suggest that most respondents in this study seem to attribute a person’s ability in mathematics to genetics endowment. They seemed to believe that one’s mathematics ability might be inherited from one’s parents.

It follows that only if one had an inherent mathematical ability, then one would be good at mathematics. In contrast, effort and perseverance were ranked as the most important contributing factor by less than one fifth of the total respondents, suggesting that these factors were not seen as important as inherited mathematics ability in determining a person's success in mathematics.

However, 'mathematics teacher' was ranked by 5% more of the respondents in this study as the most important attributing factor for some people to be better in mathematics than the others, as compared to the factor 'effort and perseverance'. This finding raises the issue of the important role of mathematics teachers in the learning of mathematics as perceived by some respondents in this study.

In terms of belief about gender differences in mathematical ability, the majority of the sample (78.5%) believed that both men and women can be equally good at mathematics. Only 15.0% of them believed that men are better and 6.6% believed that women are better in mathematics. This result seems to challenge the widespread belief that mathematics is a male-dominant subject and that men are better in mathematics than women are. Indeed, this finding might be viewed as a positive and encouraging sign that the promotion of equal opportunities in education for both genders might have changed the public's views about equity in mathematical ability. Of course, the latter claim should be treated with caution, as this result is limited by the nature of the sampling used in this study.

IV.2 Comparison between genders

I first compared both male and female respondents' belief about mathematical ability. I

Table 5.12: Beliefs about gender differences in mathematical ability between males and females

found no major differences. However, when the respondents were asked regarding which gender is better in mathematics, some interesting results with striking differences were observed. Table 5.12 displays the results. Although the majority of the respondents believed that both men and women could be equally good at mathematics, about 16% more of the females held the similar belief as compared to the males. On the other hand, there were 13% more males than females who believed men were better than women in mathematics. The results thus suggest that there were more male respondents viewed mathematics as a male domain than the female respondents. Another implication might be that the majority of the female respondents believed that they could be equally good but not better than their male counterparts in mathematical ability.

IV.3 Comparison among the different age groups

With regard to their espoused belief about mathematical ability, no major difference was observed among the different age groups. All the age groups ranked inherited mathematical ability, followed by mathematics teachers as the two most important contributing factors for why some people are better in mathematics than others.

Table 5.13 Beliefs about gender differences in mathematical ability among the different age groups

In terms of gender differences in mathematical ability, some striking differences were observed among the different age groups. The detailed result is shown in Table 5.13. The young people group aged between 17-20 (6% more than all the other age groups) espoused the belief that men are better in mathematics than women. On the other hand, the oldest age group (aged 50 years old and above) show the least believe that both genders are equally good in mathematical ability.

IV.4 Comparison among the different occupational groupings

There were some interesting variations among the different occupational groupings with regard to their espoused belief about mathematical ability. All the professionals and the skilled workers of this sample agreed that some people are better in mathematics than others. In contrast, the mathematics students (85.1%) show the least believe regarding this issue.

Similarly, with regard to the belief about gender differences in mathematical ability, some interesting differences were found. Table 5.14 displays the findings. Both the mathematics teachers and the non-mathematics teachers were the two groups with the majority of them believed that both genders are equally good in mathematics. No respondent from the non-mathematics teachers' and the professional group believed that women could be better in mathematics than men. However, the professional group tops the list of those believed that mathematics is a male domain, and this is followed by the non-mathematics students.

Table 5.14: Beliefs about gender differences in mathematical ability among the occupational groupings

	Occupational grouping								
Who is better?	Maths teachers (n=29)	Maths students (n=47)	Non-maths teachers (n= 38)	Non-maths students (n=117)	Professi-onal (n=63)	Manager (n=85)	Skilled (n=81)	Unskill (n=65)	Unemployed and Others (n=23)
Men	3.4%	14.9%	7.9%	20.5%	23.8%	15.3%	14.8%	4.6%	17.4%
Women	6.9%	6.4%	0.0%	1.7%	0.0%	10.6%	9.9%	15.4%	8.7%
Both /same	89.7%	78.7%	92.1%	77.8%	76.2%	74.1%	75.3%	80.0%	73.9%

In summary, the results in this study seem to suggest that some respondents, particularly from the male professional group and the young non-mathematics students (aged between 17-20 years old) group, still holds to the widespread myth that 'mathematics is a male domain'.

V. Views about the importance of school mathematics

The sample was asked whether mathematics is important or not. If it is important, what is mathematics important for. Five reasons such as ‘it is useful in everyday life’; ‘it helps industry and commerce’; ‘it helps citizens exercise their rights in society’; ‘it is part of our shared culture heritage’ and ‘it teaches moral values’ were given as choices. The sample was then asked to rank these five choices according to their importance, from the most important to the least important.

When analysing these responses, I encountered two similar problems as I have in Section IV. Firstly, there were 10 respondents who marked up all the choices that they thought were important, without ranking each of them. I discarded them because these responses failed to show any ranking of importance. Secondly, 37.8% of the respondents did not rank all the choices given, but instead they ranked either one or more of them. As a result, the percentage of no response for some statements was rather high. This is shown in Table 5.15. As these 'no-response' statements were rejected by the sample, I have interpreted them to provide an indirect indication that these statements were considered not to be part of the main rationale for school mathematics. Thus, I assumed that the higher the percentage of no response, the less important statement of reason is considered to be. In the end, to be consistent with the method used in ranking (as in the earlier Section IV), I decided only to use the most important factor identified by the respondents to indicate the ranking of the reasons for the importance of school mathematics. Similarly, as a result of the above problem, the total number of choices of the most important reason was 598 for the whole sample.

V.1 The whole sample

The result shows that the majority (96.4%) of the sample agreed that mathematics is important and the most important reason chosen was that 'it is useful in everyday life' (62.9%), followed by the reason that 'it helps in commerce and industry' (22.7%). Table 5.15 displays the ranking of importance for each attribute and the percentages of selection and no responses.

Table 5.15: The ranking of importance for each statement of reason and the percentages of selection and no response

The result thus reflects the emphasis on the utilitarian aspect of mathematics. Perhaps this is not a surprise because the utilitarian values and the practical usefulness of mathematics in everyday life and in commerce and industry have been the main focuses of our contemporary mathematics education in school.

On the other hand, only 3.3 % of the sample ranked the reason, 'it teaches moral values' as the most important reason and 37.8% of them did not choose it as a reason at all. Similarly, more than one third of the sample did not choose 'it helps citizens to exercise their rights in society' or 'it is part of our shared culture heritage' as their reasons. These results seemed to suggest that the societal, cultural and moral aspects of mathematics education were not valued or perhaps not understood by many respondents of this study.

V.2 Comparison by gender, age group and occupational grouping

In this section, I made a comparison of the data by gender, age and occupational groupings. I found that there was little observed difference in the ranking patterns of the five suggested reasons among the different subgroups. All the subgroups agreed that mathematics is important but is most important for its utilitarian values. Although this finding is far from conclusive, nevertheless it might lead us to reflect on the public's view about the importance of school mathematics. It seems to indicate that most people (at least in this sample) viewed the importance of mathematics to be related to its utilitarian values, and less so for appreciation of its societal and cultural values. In addition, further analysis shows that this view was held most strongly by the young people group (aged between 17-20). Therefore, linking this view with the predominant dislike of mathematics among the young people (see Section I.2), I speculate that this might be a possible reason why many young peoples showed a negative image of mathematics or a dislike of mathematics. This is because it is not sufficient to emphasise on the utilitarian aspect of mathematics, but also the appreciation of the cultural and societal importance of mathematics, in order to sustain these young peoples' interests in mathematics and to promote a deeper appreciation of mathematics education.

VI. Beliefs about the nature of mathematics

In this section, I aimed to explore the sample's images of mathematics through their espoused belief about the nature of mathematics. I adapted six statements about the nature of mathematics from past studies (e.g. Ernest, 1988). Broadly speaking, these statements were used to reflect an absolutist view (e.g. the statement 'mathematics is exact and certain'), an instrumental view (e.g. the statement 'mathematics is a collection of rules and procedures'), and fallibilist view (e.g. the statement 'a mathematical problem can be solved in different ways' etc). Table 5.16 lists the six statements that the sample could choose from and the percentage of responses of either agreed ('Yes'), disagreed ('No') or uncertain /neutral ('unsure'). In the following subsections, I will first report the result by the whole sample and follow with a comparison between the different subgroups.

VI.1 The whole sample

The result shows that 86.5% of the sample agreed that a mathematical problem could be solved in many different ways. More than 70% of them agreed that mathematics is a collection of rules while puzzles and games are proper mathematics. However, almost half of the sample was uncertain about the statement 'mathematical knowledge will change rapidly in the near future'.

The results indicate that although most respondents believed that mathematical problems could be solved in many different ways, many of them also viewed mathematics as a collection of rules and procedures that will not change rapidly in the near future. These beliefs suggest that most respondents appeared to hold a static view (Grigutsch and Torner, 1998) about the nature of mathematics, that is mathematical knowledge is viewed as a system of knowledge that is relatively unchangeable. Implicitly, these views may be closely related to the relative unchanged school mathematics contents experienced by many people in school. In addition, as many respondents viewed mathematics as a collection of rules and procedures, thus games and puzzles that involved application of these rules and procedures were included as mathematics proper. Moreover, further analysis shows that there were no strong correlation between these statements, suggesting that these respondents might have

Table 5.16: Belief about the nature of mathematics and the percentage of responses

	Yes

subscribed to more than a single view of mathematical knowledge. In other words, it was not possible for me to classify their responses to represent a particular view such as absolutist or fallibilist view of mathematical knowledge.

VI.2 Comparison between genders

Table 5.17 displays a comparison between male and female respondents on the percentages of agreement to the six statements given. The table shows that only two statements were very different. There were more females than males agreed that mathematical knowledge would change rapidly in the near future. However, the reverse is true for the statement of 'there are constantly new discoveries in maths'. This result suggests that both male and female respondents of this study seem to share rather similar beliefs about the nature of mathematics.

Table 5.17: Belief about the nature of mathematics by gender

VI.3 Comparison among the different age groups

I also made a comparison among the different age groups. The result is displayed in Table 5.18. It is interesting to note that the different age groups varied their beliefs markedly on two statements, namely, 'a mathematical problem can be solved in different ways’ and ‘puzzles and games are proper maths’. The oldest age group (50 and above) was the least to agree on these two statements as compared to all the other age groups. Although not a large effect, there were 3% more respondents from the oldest age group who believed that mathematics is exact and certain than the other age groups. Thus, this result leads me to speculate that the oldest age group seems to hold an absolutist view of mathematics, which is characterised by exact mathematical knowledge and that mathematical problem is only solvable by a certain method. Moreover, they may have considered games and puzzles to be not serious in nature because most games and puzzles might be solved by multiple approaches. As a result, these elderly respondents might view games and puzzles to be not mathematics proper. However, these claims are merely speculative without any substantive research

Table 5.18: Belief about the nature of mathematics by age group

	53.8%

evidence.

VI.4 Comparison among the different occupational groupings

Table 5.19 displays the comparison among the different occupational groupings on their belief about the nature of mathematics. Four out of the six statements given vary significantly among the different subgroups. Thus, the result indicates that occupational experiences may have some influence on people's beliefs about the nature of mathematics.

Table 5.19: Belief about the nature of mathematics by occupational grouping

Statements	

For example, both the mathematics teachers and mathematics students were the majority who believed that there are constantly new discoveries in mathematics but the least to believe that mathematics is rules and procedures, and that mathematical knowledge is certain and exact. Thus, they seem to exhibit some characteristics of a fallibilist view (Ernest, 1991) of mathematics, whereby mathematical knowledge is viewed as not necessarily objective, certain or exact, and mathematical truth can be fallible.

In contrast, the managerial and technical subgroup seems to be the majority who agreed that mathematics is a collection of rules and procedures and mathematical knowledge is certain and exact. In addition, there appear to have a trend that the higher the social class, the less they agreed that mathematical knowledge would change rapidly in the near future. However, the overall pattern of responses is too dispersed to draw out a conclusive remark that the higher social class seems to hold a more absolutist view while the lower social class a more fallibilist view of mathematics.

VII. Public images of mathematicians and their works

VII.1 The whole sample

The sample was given a list of 12 possible characteristics of a typical mathematician to choose from. 20 of them (3.6%) expressed the view that they did not believe that there was a typical image for a mathematician. One respondent remarked that "a typical mathematician is someone who knows mathematics. I don't think you can stereotype [him]" (R030) while another respondent added that "obviously (a mathematician) could be anyone" (R506). Nevertheless, this question on the characteristics of a mathematician was responded by the 85% of the respondents. Besides the 12 characteristics given, some suggested additional characteristics such as "boring" (R086), "weird and unsociable" (R532), "rigid outlook" (R348), "badly dressed, impatient and snappy" (R285) or "logical" (R490). Interestingly, two postgraduate mathematics students (whom themselves may be considered as potential mathematicians) also gave additional remarks, such as a typical mathematician is "private and sensitive (emotionally)"(R192) and "ill looking, pale and bearded" (R281).

Table 5.20 displays the list of characteristics chosen, ranking from the highest to the lowest in terms of percentage of responses. The result shows that more than half of the sample (58.4%) chose 'intelligent' as one of the characteristic of a mathematician.

Table 5.20: Characteristics of a mathematician

Characteristics	% of response (N=548)
Intelligent	58.4%
Serious	38.7%
Confident	27.7%
Male	25.9%
Wear glasses	25.5%
Odd/funny	23.0%
Strict	17.9%
Introvert	17.0%
Tidy/neat	17.0%
Bald	15.9%
Smart looking	9.7%
Female	7.5%

38.7% chose 'serious' while 27.7% chose 'confident'. About a quarter of the sample's image of a mathematician was dominated by a male who wears glasses. However, only 7.5% of them believed that a typical mathematician might be a female. Thus, the result of this study seems to suggest that a typical mathematician is portrayed as an intelligent, serious and confident male who wears glasses, and a few of them may behave differently from the general norm. This finding is interesting because implicitly, it seems to support the widespread myth that 'mathematics is only for the clever ones' and 'mathematics is a male domain'.

VII.2 Comparison by gender, age group and occupational grouping

In comparison between the males and females, I found both genders appeared to hold the similar image of a mathematician as described above. Similarly, I found no marked difference in the different age groups' images of a mathematician. Although most of the occupational subgroups also shared the similar image of a mathematician, the mathematics teachers seem to perceive a mathematician slightly differently. The mathematics teachers viewed a mathematician as someone who is intelligent, confident, odd or funny, strict and tidy, rather than as a serious male who wears glasses.

VII.3 Images of how a mathematician finds new knowledge

After exploring the public's images of a typical mathematician, I thought it might be interesting to explore how the public viewed the way a mathematician finds new knowledge. This is because the public's images of how a mathematician finds new knowledge may reflect indirectly the public's images of a mathematician, and implicitly their images of mathematics too. I suggested nine possible ways for the respondents to choose from. Figure 5.9 lists the nine suggested ways of how a mathematician finds new knowledge and displays the frequency distribution of responses of the whole sample.

The result shows that 80% of them agreed that mathematicians find new knowledge by testing examples with formulae. Only less than 3% disagreed with this suggestion. This is interesting because the result seems to correspond with my earlier findings (see Section III.2.4) that 25 respondents gave their images of mathematics as merely formulae and equations. Perhaps, the first or the only mathematician that most people have encountered might be their mathematics teachers in school. Thus, I speculate that the result may reflect indirectly how mathematics was taught in school. If many of them have had learnt mathematics in school mainly through using and applying formulae, then it will not be a surprise that consequently, this kind of teaching approach might have caused them to think that this is also the way how mathematicians find new knowledge.

The next common cluster of possible ways indicated by more than 60% of the sample was ‘discovering, creating or inventing new mathematical formula or ideas’. In addition,

Figure 5.9: Frequency distribution of responses to the nine suggested ways of how a mathematician finds new knowledge of the whole sample

64% of them agreed that mathematicians carry out complicated calculations in order to gain new knowledge. Slightly more than 53% of them agreed that mathematicians find new knowledge by solving real world problems or trying to falsify other people’s formulae. However, only about 28% of the respondents agreed that mathematicians find new knowledge by guessing mathematical rules.

These results indicate that most people, at least in this sample, viewed the work of a mathematician to be similar to the work of a scientist. They believed that the mathematicians' work is mainly discovering and creating new formulae and rules as well as inventing new mathematical ideas for others to use. More than 70% of them disagreed or felt unsure that mathematicians could find new knowledge by guessing mathematical rules. Perhaps this is not a surprise as my earlier results (see Section VI.1) show that 57.5% of the respondents have agreed that mathematical knowledge is exact and certain. Consequently, this might suggest that there is always a right way of doing mathematics. It follows that it will not be possible to gain new knowledge by guessing (as there is element of uncertainty), but instead testing with formulae might be a more likely or definite way.

VII.5 Comparison by gender and age group

There was no observed difference between males and females on their images of how a mathematician finds new knowledge. However, among the age groups, there were differences on their views on two statements. These are 'discovering new formulae' and 'creating new formula and rules'. The detailed results of this subsection are displayed in Tables F.1 (Appendix F).

Moreover, there appear to have a decreasing trend in the percentage of responses from the young people (aged between 17-20) to the oldest age group (aged 50 and above) for these two statements. For both statements, the differences were rather striking because it was about 20% higher for the young people group as compared to the oldest age group. The result seems to suggest that the older generation might have perceived the way mathematicians find new knowledge differently, such that the older a person is, the less likely that they believed that mathematicians find new knowledge through discovering and creating new formula and rules.

VII.6 *Comparison by occupational groupings*

Unlike the comparisons between genders and age groups, a comparison among the different occupational groupings indicates some striking differences and some general trends. The full results of this subsection are displayed in Table F.2 (Appendix F).

First of all, out of the nine statements, seven of them showed marked observed differences. The data thus suggest that people from different occupational groupings may have viewed the way a mathematician works differently.

Secondly, there appears a general trend linking the social class (by occupation) with their images of a mathematician's work in five of the statements. These include mathematicians find new knowledge by inventing, creating new formula, using their intuitions, solving real world problems, and trying to falsify other people's formula. The trend is such that the percentage of responses decreased from the professional subgroup to the managerial, skilled and unskilled subgroups. This leads me to infer that the higher mathematical qualification a person has (as most professionals tend to), the more they are confident about how a mathematician works. The much lower percentages of response given by the lower social classes might be interpreted to mean that these people were less familiar with the way a mathematician works.

Lastly, There was 30% more mathematics teachers believed that mathematicians find new knowledge by guessing mathematical rules than all the other subgroups. While for the whole sample, this was the least item chosen as a way for a mathematician to find new knowledge. In addition, more than 85% of the mathematics teachers believed that the mathematicians find new knowledge by falsifying other people's formula and by using their intuitions, but these two suggested ways were agreed by only a minority of the other occupational subgroups. Thus, the result shows that the mathematics teachers (in this study) seemed to exhibit a rather different image of a mathematician as well as how a mathematician works.

5.4 Summary of Chapter 5

In brief, the main findings of the stage one of this study can be summarised as follows:

1. On the whole, more than half (53.8%) of the sample responded that they like mathematics and one third of them stated that they do not like mathematics. However, not all those who reported a liking of mathematics experienced positive feelings when they thought of learning mathematics in school. Likewise, not all those who reported a dislike of mathematics experience negative feelings towards learning mathematics in school. This shows that there is a disparity between the sample's espoused liking and feelings towards learning mathematics in school. Indirectly, the result shows that the instrument used was able to probe into the sample's attitudes by triangulation. That is, asking different questions to probe for the same construct, 'attitude towards mathematics'.

2. Generally, the images of mathematics of the sample are characterised by expressions of feelings and attitudes, followed by the category of the nature of mathematics. Most respondents held an image of mathematics as a 'difficult’ (f=70) or 'boring’ (f=58) subject, or related to 'numbers and symbols' (f=46). Similarly, their images of learning mathematics were also characterised more by expression of attitudes or as a process of learning. Some common images of learning mathematics are: Learning mathematics is like 'having a tooth pulled out' or watching paint dry' or 'finding your way through a maze'. These metaphors indicate feelings of anxiety (f=87) or boring (=38), or a process of problem solving (f=32).

In general, dualistic view of mathematics as ‘right or wrong’ and absolutist view of mathematical knowledge as ‘certain and exact’ are also prevalent in the sample’s images of mathematics. This type of view is particularly dominant among the young age group and among those who dislike mathematics. It is also prevalent among the skilled and unskilled working groups. Consequently, these inclinations might explain the more dominant belief about their lack of mathematical abilities as well as the more negative expressed feeling that exhibit among these subgroups.

3. The majority of the sample believed that some people are better in mathematics than others and they attributed this mathematical ability to have inherited from parents. While mathematics teachers play the second important role in deciding a person’s better in mathematics, effort and perseverance were not perceived as important as inherited mathematical ability. These beliefs about mathematical ability and its possible contributing factors were rather similar between both genders and among the different age and occupational groupings.

However, the belief about gender differences in mathematical abilities varies significantly between gender, age and occupational groupings. The male respondents tended to believe that men are better in mathematics but the female respondents tended to believe that both men and women are equally good at mathematics. In terms of age grouping, the young people and the oldest age groups were the least to believe that both men and women are good at mathematics. Instead, they believed that men are better in mathematics than women. Striking variation among the occupational groupings suggests that career might have impact on people’s belief about gender differences in mathematical ability. The teacher groups were the majority who believed that both genders have equal ability in mathematics. But the professionals and the non-mathematics students were the two dominant groups, which held the belief that mathematics is a male domain.

4. The majority of the sample agreed that school mathematics is important and its importance has been viewed as closely related to its utilitarian aspect, but less so for appreciation of its societal and cultural values. There is little observed difference in the ranking pattern of the five possible reasons among the different subgroups of the sample. However, the view that mathematics is important merely for its utilitarian aspect has been most strongly held by the young people subgroup.

5. Although the majority of the sample believed that mathematical problems could be solved in many different ways, many of them still viewed mathematics as a collection of rules and procedures that will not change rapidly in the near future. Both genders seem to share a rather similar belief about the nature of mathematics. However differences in age and occupation seem to have some impact on the respondents’ belief about the nature of mathematics. The oldest age group tended to exhibit an absolutist view of mathematics than all the younger age groups. Likewise, the managerial and technical subgroup also exhibits this tendency of viewing mathematics as a collection of rules and procedures. However, the mathematics teachers and mathematics students seem to hold a more fallibilist view of mathematics than all the other subgroups.

6. On the whole, the sample seem to believe that mathematicians find new knowledge by testing examples with formulae more than by guessing mathematical rules. While there is no observed difference in the males and females’ images of mathematicians' way of knowing, there is a general trend of decreasing percentage of responses from the young age group to the oldest age group. The young people group (aged between 17-20) tended to believe that mathematicians find new knowledge by creating and discovering new formulae than all the older age groups.

On the other hand, in terms of occupational grouping, the respondents' images of mathematicians' work seem to vary and correlate with their social class (classified by occupation). The results show that the higher the respondents' social class and hence their mathematical qualifications, the more they tend to believe that mathematicians find new knowledge by inventing and creating new formula, using their intuitions, solving real world problems and trying to falsify other people’s formula. Conversely, the lower the social class of the respondents, the less certain they were about the way a mathematician works. Perhaps this finding was not a surprise because the respondents of the higher social class might presumably have higher qualification in mathematics, and thus more familiar with mathematicians' work than their counterparts from the lower social class.

In addition, it is interesting to observe that the mathematics teachers in this study seemed to exhibit a rather different view about a mathematician’s work from all the other subgroups. They seemed to emphasise on falsifying, using intuitions and guessing mathematical rules as the more possible ways for a mathematician to find new knowledge than all the other subgroups of the sample.

In conclusion, the analysis of the data collected in stage one of this study thus provide me a glimpse on the sample's images of mathematics. However, to probe deeper into the possible underlying factors and influences on their images, I shall now analyse the data collected in stage two of the study. This will be reported fully in the following chapter.

Chapter 6

Findings of Stage Two

This chapter lists the main objectives, and reports the findings of stage two of this study. Stage two is a follow-up telephone interview of approximately 10% of the stage one sample.

6.1 Objectives of Stage Two of the Study

In stage one, I explored selected key aspects of the respondents' images of mathematics. In stage two, these aspects were further explored by interviews. In addition, I attempt to investigate the possible factors of influence or mechanisms that might have generated the images of mathematics reported by my sample. Consequently, the four main objectives of stage two are:

1. To confirm and validate the categories of images of mathematics given in stage one with a representative subsample of the respondents,
2. To explore the possible reasons for their liking or disliking of mathematics,
3. To allow the respondents to describe their mathematics learning experiences in schools, and
4. To explore other possible factors of influence that might be linked to their views and images of mathematics.

6.2 Analysis of interview data

Out of the 62 interviewees, 57 were interviewed by telephone. The remainder five opted to be interviewed face-to-face. Out of these five face-to-face interviews, one of them preferred not to be tape-recorded. Thus, the main points of her conversation were noted during and after the conversation. Similarly, due to a faulty connecting line, one of the telephone interviews was not recorded properly. Nevertheless, the main points of the conversation were noted immediately after the interview. As a result, there were 60 tape-recorded interviews and two interviews recorded in note form. All 60 tape-recorded interviews were fully transcribed. Together with the two note-taking interviews, all 62 sets of textual data were analysed using Q.S.R Nud*ist (1994) (Non-numerical Unstructured Data Indexing Searching and Theorizing, a computer software for qualitative data analysis).

Before analysing these data, several preparatory steps were taken. These include:

1. Each transcript was read several times to gain a holistic picture of each interview. Its main points were then noted in a summary sheet (see example in Appendix G). These main points were used to build up a list of categories for categorising (or "indexing" as used in Nud*ist) the data.

2. Each paragraph (or 'text-unit') of every transcript was read again before it was indexed to one or more categories or subcategories. Additional categories or subcategories were then created during the process of indexing, if they appeared to be needed to accommodate the data. The list of categories and subcategories was displayed as a 'tree' where the main trunk (the 'parent') are categories while their stems (the 'children') are subcategories (for example see part of a 'tree' display in Appendix H).

3. After indexing all the text units, each transcript was read again and was further indexed wherever relevant. The same process was repeated until I was satisfied that all the text-units have been indexed completely. This process was carried out for all the 62 transcripts. (See example of interview transcript with indexing in Appendix I)

4. To search for pattern of responses across the respondents, I used the 'search index system' to group or to collect all text-units that were indexed on the same category or subcategory. During the process of searching for patterns and explanations, some categories or subcategories were added while some were deleted. This was because it was possible to combine similar categories, and some appeared to be redundant.

5. Overall, this cycle of read-index-analyse and re-read-re-index-re-analyse was repeated many times until I was satisfied that all the data have been fully analysed, and both the categories and the categorisation of the data was stable. (The final list of categories (indexes) with definition is given in Appendix J)

In the following section, I shall first discuss the general trends that have emerged from the data with regards to reasons given by those who reported liking and those who reported disliking of mathematics. Next, I explore the possible factors of influence contributing to their images of mathematics. Thirdly, I compare the general trends among the different genders, age groups and occupational groupings. Lastly, some exemplary cases of those who reported liking and those who reported disliking were given.

6.3 Results and findings

An immediate trend that emerged from the data was that there exist significant differences in the images of mathematics exhibited between those who reported liking and those who reported disliking mathematics. These differences were found in their reasons for liking or disliking mathematics, their images of mathematics and learning mathematics, their school experiences in learning mathematics and their experiences with mathematics teachers. Accordingly, I report and discuss these findings in the following subsections:

I. Reasons for liking mathematics

II. Reasons for disliking mathematics

III. Images of mathematics

IV. Images of learning mathematics

V. Experiences of learning mathematics in school

VI. Possible factors of influence

VII. Other Issues

Out of the 62 interviewees, 36 reported a liking of mathematics while 26 reported a dislike of mathematics. There were 24 males and 38 females. Detailed frequency distribution of the interviewee according to age, occupation and gender is displayed in Tables C.4 and C.5. (Appendix C).

In the following sections, all quotations given were quoted exactly from the interview transcripts. I acknowledge that some of these quotations are not in the form of standard English. There are four possible reasons or causes: (a) these are given in spoken English; (b) my sample varied widely in terms of occupation and educational qualifications, and some spoke using colloquialism; (c) the interviews were tape-recorded through telephone, and not all responses were audible; and (d) as a foreigner, I might be lacking or limited in terms of linguistic or cultural knowledge of the native language and misinterpret some utterances. To minimise the last two problems, I have constantly tried to check my understandings with the respondents during the interviews, as well as checking with my British colleagues, and my supervisor whenever there was any doubt about my understanding of the language. (detailed discussion of the validation of interview data was given in Chapter 4).

I. Reasons for liking mathematics

(i) motivated because they are 'good at it' and 'can use it'

The most common reason given for liking mathematics was "because I can do it" (R133, text-unit 3) or "because I was good at it" (R293, text-unit 17). Out of the 36 respondents who reported a liking of mathematics, 14 of them gave these similar reasons. Moreover, one sixth of them (6/36) expressed the view that they like mathematics because they use mathematics successfully in either their work or everyday life. For example, "Obviously I used it in my job quite a lot, that's the reason why. I need it for everyday." (R328, text-unit 3) or "Hmm, perhaps it is because I don't have any problem with mathematics. I am quite happy to use it at home and at work" (R239, text-unit 3). Thus, for some respondents who reporting liking mathematics, they seem to like mathematics because they believe that they are 'good at it', and they are confident in using mathematics at work or in daily life.

(ii) the problem solving aspect of maths

The second most common reason for liking mathematics is "have great fun in solving mathematical problems" (R061, text-unit 5) or "finding solution to problems" (R119, text-unit 3). About a third of them (11 out of 36) expressed that they like mathematics because they enjoy solving mathematical or numerical problems. For many of them (8 out of 11), this holds true since their school days.

(iii) the logical nature of mathematics

Closely related to the problem solving aspect of mathematics, a number of respondents gave their reason for liking as "the fact that it is usually logical and also a matter of problem solving" (R491, text-unit 3) or "I enjoy learning the logic of mathematics and understand where things come from" (R534, text-unit 3). Others found that "it is a kind of logical relationship between numbers that I find interesting"(R061, text-unit 7). There were 8 out of 36 of those who expressed a liking of mathematics seemed to relate their reasons for liking to the logical or systematic nature of mathematics. They like mathematics because it involves logical thinking especially when solving mathematical problems.

(iv) the power of certainty or getting the right answer

One quarter of the respondents (9 out of 36) reported that they like mathematics because they believe that mathematics has the power of certainty or there is a certainty in mathematical answers. One science teacher gave her reason of liking as

> I still like being able to get [solve] mathematical problem, for example solving trigonometric equations and I just like the fact that you could get a solution and that nobody could say that you have done wrong. (R113, text-unit 7)

Other similar views were:

> I like the fact that it can give you something definite, just that mathematics that we used everyday. That is always an answer to that. (R205, text-unit 3)

> I like problems where one can have an exact solution to things, where one has elegant proof. (R191, text-unit 9)

Moreover, as a result of this certainty in mathematical answers, some of them found solving mathematical problems satisfying or rewarding, especially when they were able to get the correct solution to the problem:

> I probably enjoy a problem that set to me and I enjoy trying to solve them. Obviously if I can get the right answer, I feel achieving and rewarding. (R409, text-unit 11)

> I think it is very satisfying to do something where you know your answer is right, and where you can work through a process logically. That is why I like maths. (R220, text-unit 3)

These responses seem to suggest that many people's reasons for liking mathematics are centred around problem solving and its related aspects such as its logical nature and the possibility of getting the 'right answer'.

(v) as a challenge

Other reasons given for liking were:

> I like the challenge, a mental challenge (R534, text-unit 3);

> It will have to be just sort of challenge, of having problems and the use of mathematics to work it out…. (R370, text-unit 3) or

> It is a challenge. If you know how to do it, you can get the answer. That is what challenges. (R533, text-unit 3)

These responses suggest that mathematics is viewed as a kind of mental challenge. Five respondents who reported a liking of mathematics shared this view. Although one of them expressed that he found mathematics "quite difficult to learn"(R328, text-unit 19), but he still "quite enjoy that sort (the challenge) of it, really." (R328, text-unit 19)

(vi) beauty of mathematics

One respondent expressed his reason for liking as "I think I like the elegance of mathematics. The proofs and theories of mathematics are very elegant. There is … like recognising the patterns of mathematics, I found it very very interesting. " (R193, text-unit 3) Four respondents quoted their reasons for liking mathematics in relation to the beauty of mathematics, such as the elegance of proofs and the presence of pleasing patterns within mathematics. Out of these four, three are males and one female, while two of them are mathematics teachers and one mathematics researcher. Thus, this reason for liking seems to be given more often by those who have direct involvement in mathematics. However, the numbers are so small that no firm conclusion can be drawn.

Summary of reasons for liking mathematics

In summary, the reasons for liking of the respondents can be grouped under two main themes:

1. Some respondents claimed to like mathematics because they are confident in their mathematics ability (e.g., they believed that they are good at it). Moreover, they appreciate the practical value of mathematics as they can use it at work and in daily life. A small number of them claimed to like mathematics because they appreciate the beauty of mathematics.
2. Some respondents claimed to like mathematics because they like the problem solving aspect of mathematics. They believe that mathematics is logical in nature and it has the power of certainty (such as getting the right answers). Although some of them might find mathematical problems difficult to solve, they take it as a mental challenge, and they find great satisfaction, especially when they obtain the right answers or solutions to problems.

II. Reasons for disliking mathematics

(i) Feeling of inadequacy or 'not good at it'

The most common reason for disliking mathematics was given as inadequacy or not being good at mathematics. For example:

> Hmm, I just wasn't very good at it when I was at school. That's all. (R016, text-unit 3)

> Well, I don't think I have ever grasped it very well right from my early school days, so… And my mental arithmetic has always been very poor. (R279, text-unit 3)

Out of the 26 respondents who expressed disliking mathematics, nine of them claimed to dislike mathematics because they believed that they were not good at mathematics or at certain areas of mathematics. They seemed to feel inadequate and this was presumably related to their experiences of limited success and failure in school mathematics. When they were asked to describe their experiences of learning mathematics at school, one of them described her experiences as

> At school anyway, I seem to just get everything wrong and then there is another thing, which I don't seem to entangle something when I got it wrong. I just [got] more and more confused. (R396, text unit 15)

Further analysis of the data shows that seven of these respondents experienced some failures in school (e.g., one respondent (R268) failed her GCE 'O' level three times and another respondent (R153) her CSE exam three times too). In addition, some cited their experiences of poor teaching at some point in their school lives, mostly at secondary school or at Advanced-level mathematics.

(ii) The belief that mathematics is only for the clever ones

Some respondents stated that they dislike mathematics because they believed that:

> I don't have a natural talent for it. (R207, text-unit 3) ;
>
> It has got the image of, hmm, for clever people, it sorts of put people off from the beginning. (R338, text-unit 3).
>
> I think mathematics has been put across to me as something incredibly difficult and only very clever people can do it and you (she) are not one of the people. (R374, text-unit 27)

There were seven respondents whose dislike of mathematics related to their belief that they do not have the ability to learn mathematics, or that only clever people can do mathematics. One PhD student explained his reason of dislike as follows:

> I think it is because I am not very good at it. And other people who are better than me, which I think (they) really like. So, that sort of thought kind of influences me. (R548, text-unit 3)

Thus, these respondents tended to compare their ability with others and believe that they do not belong to the group.

(iii) Difficulty in understanding, confusion and blame on teachers

Another common reason given for dislike of mathematics is that:

> Well, I didn't like it because I didn't understand it for a lot of the time. And I found everything very frustrating when I couldn't understand it (R025, text-unit 3)
>
> It is difficult for me. I don't have the understanding. (R462, text-unit 3)

Seven respondents expressed their view that mathematics is a difficult subject for them because they found it confusing and hard to understand. Others expressed their reason for disliking mathematics as follows:

> Hmm, I think it is because when I was at school, I have a really horrible teacher. I don't know, he really put me off. I get very confused and I can never understand what is going on. I also do not know why I get that answer. (R284, text-unit 3).

> I was taught badly so I find I don't really understand it very much, so I have concentrated on words and philosophy. (R399, text-unit 3)

> I think I hardly have any respect of my maths teachers because I don't think they were teaching me in a way that I could understand. Why were they telling me this? What relevance does it have? What is so important about this? (R218, text-unit 9)

These responses show that some respondents seem to relate their failure to poor mathematics teaching. There were 16 respondents who reported disliking mathematics shared this similar view.

(iv) expressed strong negative feelings such as 'hate'; 'cold' or 'struggle'

When asked for their reason for disliking mathematics, some respondents (10 out of the 26) expressed strong negative feelings such as "I hate it" (R042, text-unit 3); "It leaves me feeling cold" (R218, text-unit 29); "It is dull"(R338, text-unit 3). One of them likes to associate things with colours and she described her feelings of mathematics as

> Er! Horrible! I really don't like it. It is … you know, sometimes I think things in colours. Like days in a week, always with different colours. And maths, just the sound of it is dark brown, it is black. It is nasty and is all dark gloomy colour." (R115, text-unit 21)

Further analysis revealed that many of them have had bad experiences of learning mathematics in school. One of them (R153) has to sit her CSE three times and only managed to pass at the fourth time. Another respondent (R115) was asked to give up taking mathematics at the age of 14 by her teacher. While another respondent (R548) said he hated mathematics because he was demoted from the top set to the bottom set at GCSE, and from then on, he changed his view of mathematics to a very negative one.

Summary of reasons for disliking mathematics

(i) Contrary to those who claimed to like mathematics, people who expressed a dislike of mathematics tended to feel that they lack the ability to learn mathematics and thus they are not good at it. They also tended to compare themselves with others and commonly believe that mathematics is only for the clever ones.

(ii) Many of those who claimed to dislike mathematics found mathematics difficult to understand and some found mathematics confusing. However, unlike those that claimed to like mathematics and who see the difficulty of mathematics as a challenge, those who claimed to dislike mathematics tended to blame their teachers. They appeared to believe that they could not understand or would become confused because they were not taught properly or that they have been taught badly. This raises the issue of the great importance of the mathematics teacher for those who claimed to dislike mathematics, much more so than for those who claimed to like mathematics.

However, I acknowledge that any such generalisation must be treated with great caution, as all my data says is that some of my respondents claimed that mathematics teachers had a great influence on them. But I have no direct data on this.

III. Images of mathematics

A. Images of mathematics as related to nature of mathematics

(i) The image of mathematics as certainty in answer or dualism

The most common image of mathematics given by those who reported a liking of mathematics was that it always has a right or wrong answer. For example, "you always get an exact answer in mathematics" (R533, text-unit 5) or "I just feel, when you first learn a topic, especially with mathematics because there is always a right answer." (R534, text-unit 9) There were 13 out of 36 who claimed to like mathematics expressed their images of mathematics as having certainty or definite right or wrong answer.

With further probing, one of them believed that there is no absolute certainty in any mathematical solution. However, he asserted that "for the level that I have done, yes. You can use a number of different ways to get the right answer, but it's nice for me to be able to come with the right answer."(R120, text-unit 5) Thus, to some people, this certainty holds at least for the level of mathematics that they have acquired.

Similarly, one mathematics student described her view of mathematics, after taking up a teacher-training course as follows:

> Yes, I mean we always brought up with that of the right or wrong answer and suddenly we were told that was not the most important part of mathematics, the most important is how to get there, what kind of strategy to use. … Therefore, mathematics does not have a definite solution. It is really your journey to get there. (R133, text-unit 13).

It thus shows that for some respondents, this view of certainty might change over time or as they change their careers. One ex-primary schoolteacher, who is now an administrator asserted that, "mathematics is not always right or wrong but depends on context." (R122, text-unit 24)

In addition, this image of mathematics as "it's got an exact answer, so it's worth working towards" (R533, text-unit 5) or "…obviously if I can get the right answer, I feel achieving and rewarding" (R409, text-unit 11), seems to provide the respondents feelings of satisfaction, it can be rewarding and confers the power of certainty.

For those who expresses a dislike of mathematics, many of them also hold similar views of mathematics. For example:

> I think for maths, it is always right or wrong answer, certainly with school maths. You have to get the right answer while English is more subjective. (R207, text-unit 39)

At least 5 out of 26 of them viewed mathematics as something that has a definite right or wrong answer. However, contrary to those who expressed a liking of mathematics, this mathematical certainty is part of their reason for disliking mathematics. One of them expressed his reason for disliking mathematics as:

> Hmm, it is kind of absolute, isn't it? You either got a right answer or a wrong answer but generally I never get the right one, ha! Ha! (R374, text-unit 3)

It seems that the certainty of mathematics has reduced their interest in the subject because they generally failed to get the right answers.

One postgraduate research student in sport science commented,

> …mathematics is sort of not very questionable, for example, probability is probability, it is difficult to question probability and things like that. …You learn trigonometry and you don't discuss trigonometry.
>
> Interviewer: Do you mean you view mathematics as a kind of truth?
>
> R548: Yes, very much. That is it and that is what we learnt. (R548, text-unit 38-39)

These responses show that some people claimed to dislike mathematics because mathematics is taken as something that is not questionable, unlike subjects in the humanities such as English and History, where the answers could be personal or reached through discussion.

(ii) The image of mathematics as a practical tool

When one administrative assistant was asked about her image of mathematics, she replied,

> When I think of maths? I will say, it is the use of figures and it is the … I guess in everyday life it is related to currency and the way of, you know, in that sense, it is the use, is to make the world go round in that way. We only need money to work so we only are able to understand how to calculate. (R121, text-unit 9)

Eleven others who expressed liking mathematics also shared this view of mathematics as related to the utilitarian aspect of mathematics. For example, "mathematics is a game or a tool for me and no more, not a way of life." (R061. Text-unit 13) or "mathematics is essential to everyday life" (R043, text-unit 7). These responses show that many of them recognised the importance of mathematics by relating it to its usefulness and relevance in everyday life especially relating to money transactions, but didn't see beyond its uses.

For those who expressed disliking mathematics, mathematics is necessary as "everybody needs to know maths" (R496, text-unit 21) because "it will be very useful for understanding many things" (R399, text-unit 33). 12 out of 26 of them relate their image of mathematics to the utilitarian importance of mathematics in everyday life and career. Even though they acknowledged this practicality and usefulness of mathematics, many of them felt that "mathematics is something need to be done rather than enjoyed" (R548, text-unit 31) or "…if it is for practical and application, then I am quite happy to do mathematics for a set of problems. But I never sit down and do it for pleasure." (R025, text-unit 22) In brief, although both of those who expressed liking mathematics and those who expressed disliking mathematics gave similar image as related to the utilitarian aspect of mathematics, the difference is that the former enjoys doing it while the latter doesn't.

(iii) The image of mathematics as numbers, equations and formulas (symbolism)

The next most common image of mathematics given by those who reported liking mathematics is that of symbolism. For example, "well, to me, it is calculation of numbers and figures, and just to get total of numbers really."(R394, text unit 9) or "…it is the use of figures…" (R121, text unit 9). There were 12 out of 36 in the sample referred to mathematics as closely related to numbers, equations and formulas. One cashier gave her image of mathematics as "paper and pen". She explained that

> Oh, most of them are deal with some papers and pen, obviously there are some calculations and diagrams but mostly are paper or something like the log book, but is usually explaining things using numbers and figures, isn't it? (R239. Text unit 7)

In this similar aspect, many of them claimed to like mathematics because "I just quite like playing around with numbers, equations, finding solution to problem."(R119, text-unit 3) or "I am fairly enjoy working with figures" (R121, text-unit 7). Thus, these responses show that many of them enjoy mathematics because they enjoy the manipulation of numbers and figures and the use of formula to solve problems.

For those who claimed to dislike mathematics, six out of 26 in the sample gave their images of mathematics as "sums" (R016) or "calculation" (R044). Some of them realised that "sums aren't totally what maths is about, …" (R044 text unit 13), but to others, "it is used to me that mathematics is figures and numbers" (R513, text unit 55). As a result of this symbolic view of mathematics, some of them felt that "I find it (mathematics) boring, doing numbers and things like that."(R267, text-unit 37)

Comparing those who expressed liking mathematics with those who expressed disliking mathematics, it is interesting to notice that both groups hold similar view of mathematics as related to symbolism. However, the difference is the former enjoyed the manipulation of numbers while the latter found this boring.

B Images of mathematics as related to values in mathematics or education

Besides the nature of mathematics, many respondents gave their images of mathematics as related to values in mathematics or education. These values include challenge, beauty of mathematics, power of certainty, creativity, objectivity, mystery and fallibility in mathematics.

(i)Power of certainty and objectivity

Among these values, the most commonly quoted was the power of certainty. One university lecturer gave his image of mathematics as "clean and reliable" (R061). He explained that

> Well, what I mean is once you understand the rules and structures by which numbers and mathematics is being operated, then as long as you stick to that rule or that structure, you apply the rules appropriately, then you are most likely to

come out with an accepted answer and so I see it in that sense. And therefore, it is not cluttered by other things like, what I have just talked about, the relative aspect of life." (R061, text unit 15)

As I have discussed above, the belief that mathematics has the power of certainty is very closely related to the belief that there is certainty in mathematical answers.

A speech and language therapist added that, "It is something very objective about maths, ..." when she compared mathematics with writing, "Instead if you are writing or you are doing creative writing, it is so much more nebulous, it is much more difficult to know whether it is good or bad, it is so much more subjective" (R220, text-unit 19). Thus, this 'power of certainty' is also very closely linked to other values such as objectivity in mathematics.

Generally, there were three levels of beliefs with regards to the 'power of certainty'. At one end, there are those who believe that mathematics has only right or wrong answers. A librarian who claimed to like mathematics remarked that "I like the fact that it [mathematics] can give you something definite. Just the maths that we used everyday -- there is always an answer to that" (R205, text-unit 3). Thus, she believed that mathematics, in particular everyday mathematics, offers great power of certainty and objectivity. This group of people might be called 'the absolutists'.

At the other extreme, there were two respondents who believed that "it is not a certainty, in another word, that some people think it is…" (R544, text-unit 5), because "you will never find anywhere with mathematics written down with all the rules, there are just ways that we have of… solving problems in life or finding patterns." (R547, text unit 27). This minority group, whom might be called 'the fallibilists', seem to disagree totally that mathematics is certain and exact.

While the middle group is those who believed that mathematics offers the 'power of certainty' but only to certain level, such as at school mathematics, or within certain areas of mathematics. An engineer in the information technology commented that,

> No, I would say, ... As you go further on the trail, sometimes you have to use mathematics techniques to get an approximate answer which is very close to a possible true answer, but it may not be the answer....(R491, text-unit 13)

His view was supported by a lecturer who remarked that "I like to point out again, what I am very aware of is, in higher order mathematics, the certainty of it [mathematics] begins to become less and less. "(R061, text-unit 17)

These responses suggest that members of this middle group felt that there is a certainty in mathematical answers at the lower level of mathematics. However, mathematics is no longer certain and definite at higher level of mathematics. Most mathematical solutions may become "just a relative answer or estimation" (R205, text unit 13).

(ii) Creativity

In terms of creativity, those who reported a liking of mathematics espoused different opinions from those who reported a dislike of mathematics. One primary teacher who claimed to like mathematics believed that "...you can be just as creative with mathematics in solving things as you can in any other subjects... (R544, text unit 38). In contrast, a nurse who claimed to dislike mathematics commented that,

> I think mathematics is more scientific than English which is quite creative and artistic. I always thought that people who are very mathematical and scientific are precise and logical. But I am not logical at all. Or they are very creative, they like music and dancing and things like that. You know, people have to be one of these. (R268, text-unit 54)

The data show that many of those who claimed to like mathematics tend to believe that mathematics can be as creative as other subjects whereas those who claimed to dislike mathematics tend to view mathematics as lack of creativity when compared to other subjects such as English and Arts. There were also some interviewees who agreed that mathematics could be creative at a higher level but it was not so at the level of school mathematics. One librarian interviewed mentioned that "Although I didn't say maths can't be (creative) when you come to certain level, certainly maths in school isn't very creative, or wasn't" (R207, text unit 41).

(iii) The element of mystery

Both those who like and those who dislike mathematics offer the image of mathematics as having mysterious elements. They found in mathematics infinite things that are beyond their comprehension. One of them, an ecologist who claimed to dislike mathematics, described mathematics as "dreamlike, logical at times but intangible and confusing others" (R025) and she explained as follows:

> Yes, I put that because to me, I don't know, may be my trend of thought is not very logical as well as analytical, I find it quite hard to grasp. And so most of the time, I get a little bit of it and suddenly it becomes clear and I will, Oh! Ya! I understand

that. And then I felt blurred again and confused again. But something else, I am clear. So, I never really knew, I could not really see the whole picture, do you see what I mean? I never have a full understanding of everything so that I can see it clearly. I just get a little bits of it and I understood at the minute but then it goes again. So that is what I meant by maths is dreamlike. (R025, text-unit 16)

On the other hand, a mathematics teacher who claimed to like mathematics commented that,

"yes, it is infinite. I know I will never get to the end of it, I mean, I know that I will never learn or even begin to understand all there is out there…." (R286, text-unit 9) but she added that "there is a lot for me to find out, and I enjoy that journey of finding out and realising things. … " (text-unit 13)

Therefore, the difference between these two groups is that those who claimed to dislike mathematics tend to link the mysterious nature of mathematics with their

Table 6.1: A comparison between those who claimed to like mathematics and those who claimed to dislike mathematics

Reasons for liking/dislike	▪ beauty of maths (3)	▪
related to nature of mathematics :		
related to values in mathematics or education:		•

incomprehension and confusion over mathematics. However, those who claimed to like mathematics tend to take the mysterious nature of mathematics as exciting; a challenge or something to be explored further.

In summary, further analysis show that there were more of those who claimed to like mathematics (20 out of 36) gave their images of mathematics as related to values in mathematics or education than those who claimed to dislike mathematics (5 out of 26). Most of the values reported (e.g., challenge, power of certainty, and objectivity) were thought highly of and appreciated by the former than the latter, and these values were also given by some of them as reasons for liking mathematics. However, some values such as the elements of mystery and creativity were attributed to mathematics by both groups, but with different degrees of appreciation.

Table 6.1 summarises and compares the reasons for liking (disliking) of mathematics, images of mathematics as related to the nature of mathematics as well as the values in mathematics or education between the two comparing groups.

IV. Images of learning mathematics

A variety of responses was given as comprising images of learning mathematics. Among those who claimed to like mathematics, for example, one shop manager described her image of learning mathematics as "exploring things, exploring numbers and quantities, fractions, decimals, geometry and trigonometry, you know, it is exciting…"(R043, text-unit 11). Others described learning mathematics as "the best sort of travelling in new land" (R293) because "you haven't done that sort of mathematics before and you begin to realise why some statements, some theorems in mathematics are true or you begin to see the use that theorem can have, you know, the statement is making connection without the thing, and that I find interesting" (R293, text unit 9). Out of the 36 who claimed to like mathematics and were interviewed, six of them gave their images of learning mathematics as a kind of exploration or discovery of new things.

The second common image of learning mathematics is that "learning mathematics is like entering a new world of puzzles" (R401) and this respondent explained that "It is like different numbers and solutions - it is really interesting when you find out the solution, you feel very excited" (R401, text unit 7). Thus, learning mathematics is viewed as a process of solving problem and it is also usually related to the satisfaction of getting right answers or solutions.

In contrast, those who claimed to dislike mathematics have images of learning mathematics that are characterised by strong feelings evoked from the memory of negative experiences when they were learning mathematics in school. These were expressed as strong negative feelings, such as "learning maths was horrible, it was awful" (R115, text-unit 23) or having a "mental blackout-it is all gone!" (R267, text-unit 13). Many of them gave metaphors that described their experience in learning mathematics as "climbing up a steep hill" (R218, text-unit 14) or "being stuck in mud" (R153). As one of them explained, " ...it's like when you have your feet stuck in mud, you struggle to try to get them out, and that's what maths is like to me, I struggle with maths. You know, you still go forward but it is a struggle, and that's why I don't like maths." (R153, text unit 11) At least 10 out of the 26 who claimed to dislike mathematics gave their images of learning mathematics related to some kind of struggle.

Two of them also expressed their learning mathematics experience as a slow and boring process such as "watching paint dry" (R451) or "going to sleep" (R496). There were also those who view learning mathematics as "hard work" (R513) or something that you have to do but which is not enjoyable, such as "being dragged unwillingly along" (R278) or "catching fish when you are hungry! Satisfying but not fascinating,..." (R025). Others felt like "watching a foreign film without subtitles" (R284) or "driving a Boeing 707, I don't fly" (R462). This last respondent explained that,

> It is an expression I used when someone says it is easy, all you got to do is this. It is easy if you can fly and you know how to drive Boeing 707. But if you sit in front of a Boeing 707, where do you start? You know that you want to take off. You know that you want to start the engine. You want to go forward but you don't know how, so you have the interest. Sometimes the interest is there but the lack of comprehension of how the whole thing works, it means you don't progress any further. (R462, text-unit 19)

They expressed frustration and disappointment while learning mathematics because they could not understand what was taught.

The data thus shows that the images of learning mathematics given by those who claimed to like were different from those who claimed to dislike mathematics. They ranged from strong negative feelings about the process of learning to the appreciation of values in mathematics or education. For those who claimed to like mathematics, they viewed the process of learning mathematics as an exploration or a problem solving process that gave them much satisfaction especially when they managed to obtain the solutions. On the other hand, those who claimed to dislike mathematics recalled their painful experiences in learning mathematics and reacted with strong negative feelings such as remembered boredom, frustration and disappointment.

However, irrespective of whether those who claimed to like or dislike mathematics, many of their images of learning mathematics were similar to their images of mathematics. This suggests that there is often a close correlation between people's images of mathematics and their images of learning mathematics. In other words, the results suggest that one's experience in learning mathematics will possibly influence one's views about the nature of mathematics, and consequently this view might influence one's motivation and interest in learning mathematics.

V. Experiences of learning mathematics in school

(i) Positive experiences of learning mathematics in primary school

The majority of those who claimed to like mathematics (25 out of 36) recalled positive experiences of learning mathematics during their primary school years. For example, one non-mathematics student recalled that, "I have some good teachers and they all taught it (mathematics) in a very interesting way…"(R316, text-unit 35). These experiences were characterised by enjoyable, interesting and fun-based lessons given by inspiring mathematics teachers. Some remembered moments of achievement such that,

> "…and I remembered finishing, shortly after she (his mathematics teacher) had written a lot of questions and she couldn't believe that I had done it in such a short span of time. She tested me on one or two of them. I felt quite please with myself that I could do it so quickly. It was the third year of my primary school. …" (R471, text unit 15).

Most of them also enjoyed their primary school mathematics because the use of concrete materials as teaching aids has helped them to understand mathematics better. For example, "…we have this little diagram in shape of L which help you to see the fraction. I find it very easy because I can visualise that when I was doing fraction" (R 120, text unit 19). Therefore, for those who claimed to like mathematics, the majority of them enjoyed learning mathematics in primary schools because primary mathematics is relatively easy to understand, especially with the use of concrete materials. Some of them also believed that they were better in mathematics than their peers and this might have boosted up their self-esteem and interest in mathematics.

Similar to those who claimed to like mathematics, the positive experiences of learning mathematics in primary school of those who claimed to dislike mathematics were also characterised as 'more fun', 'more games' or 'more flexible' mathematics lessons. Five out of 26 interviewed mentioned the phrase 'more fun' in their conversations. One of them described her experience as follows:

> I think I kind of enjoyed it because when you were doing mathematics in the primary school, it was more, seem like, not useful but it was more sort of involving number games. All involve with numbers. I can remember using things like the abacus. All sorts of different shapes, number blocks, and I quite enjoyed that. (R356. Text unit 19)

Thus, for those who claimed to dislike mathematics, at least 9 (out of 26) of them also experienced similar positive learning experiences at primary school and using of teaching aids such as the abacus or marbles in number games.

(ii) Positive experiences of learning mathematics in secondary school

If the positive experiences of primary school mathematics is characterised by 'more games' and 'more fun', then the positive experiences of secondary school mathematics is characterised by 'more challenging' and 'better mathematics teachers'. Both those who claimed to like mathematics (23 out of 36) and those who claimed to dislike mathematics (4 out of 26), most of them found secondary school mathematics had become harder and deeper, but they had inspiring mathematics teachers who explained well and made learning mathematics easy for them. One of them described his experience as follows:

> We had a very good mathematics teacher who explained things very clearly. So, you can go into the safety of a mathematics lesson that you can work away with the problem and come out feeling you've accomplished something… (R061, text unit 27).

Further analysis shows that almost all of them credited their positive experience to their mathematics teachers whom they felt could explain well as well as encouraging their students.

In addition, one young IT trainer recalled that,

> I think when I was doing my O-level, so as when I was doing mathematics from the age of 12-16, mathematics then was not really…it was basic and it was simple in academic terms…but it was not special. When I was 17 and 18, that was the time mathematics came alive, if you like. (R193, text-unit 33)

Likewise, an artist claimed that,

> I am actually mildly dyslexic, so I am not very good at simplistic maths. When it becomes more advanced, I am actually better at that, that is why I enjoyed it more in upper secondary. (R119, text-unit 19)

Thus, some of them show increased interest during upper secondary, especially at GCSE or A-level, because they found primary and lower secondary mathematics were too basic and easy for them. Higher level mathematics seemed to lead them to a better understanding and appreciation of mathematics. Some claimed that they prefer more challenging mathematics to simple basic arithmetic.

(iii) Positive experiences of learning mathematics at tertiary level

Three of those who claimed to like mathematics quoted having positive experiences at university level. Their positive experiences were normally related to a particular area of mathematics or particularly good memory. An IT trainer related his experiences as, "there was a particular area, that was to do with 'Fourier transform'. And that again was a situation, say... Oh! I can't remember what it was now. (R193, text-unit 23) A young non-math student recalled a good experience "in college, one time that I was studying mechanic. It was a bit of course work and I got the answer right without anybody's help, that was very good and rewarding" (R533, text-unit 15). However, the majority of the sample did not study mathematics at university level. There was only one from those who claimed to dislike mathematics who mentioned positive experiences at university level. She was a teacher trainee in primary mathematics. She explained that, 'because in our university course we are doing what the primary school kids will do really. We are learning how to teach things …, we are actually doing what the primary kids will do. It is quite fun" (R284, text-unit 31). So, she was referring to primary level mathematics and she enjoyed relearning it.

(iv) Negative experiences of learning mathematics in primary school

Even for those who stated that they liked mathematics, nine out of 36 claimed that they did not enjoy primary school mathematics. One primary head teacher claimed that he did not enjoy primary mathematics,

> because I was only taught rules. I wasn't taught to actually understand what I was doing. As a pupil myself, I was never given the opportunity to understand anything. We were taught simple rules. If you do this, you will get it right. But no reasoning or logic behind it. (R158, text-unit 7)

Similarly, a language therapist recalled that her bad experiences in primary school,

> I particularly remember, many years ago, at the age of 8 or 9, we used to do mental arithmetic. I could works things out but not very quickly. And I felt very discouraged at that stage and I think I didn't, you know, mathematics is sort of not easy and I don't like that subject. It was only after I left school..." (R220, text-unit 33)

The data thus indicate that some people experienced primary mathematics as mainly consisting of rote learning of rules and mental arithmetic. Among the nine respondents, two of them found that junior school mathematics was not enjoyable because it was mainly rote learning without understanding. Another two found that they were not as quick at mental arithmetic as their peers and thus they felt discouraged. Others found that they could not grasp certain mathematical concepts and mathematics was too difficult for them. However, these negative experiences of learning mathematics at primary level did not deter them from taking higher mathematics and from developing a liking of mathematics later on.

For those who claimed to dislike mathematics, six of them claimed that they had never enjoyed mathematics learning from primary to secondary level.

> All schools right through till I left, I failed three times for my O-level. (R268, text-unit 13, a young nurse, age group 21-30).

> It was the fact that I was always left behind, people were going on ahead and I was sort of left behind in the background. (R278, text-unit 3, a retired teacher)

Moreover, the latter also recalled painful experiences in primary school where,

> having to learn a times table for each Saturday morning with the headmaster. He got several rounds and if you got one wrong, then you had 6 canes. I always remembered now that 8x8 is 64" (R278, text-unit 27, a retired teacher).

Another respondent who claimed to dislike mathematics, a musician, also recalled vivid negative experiences at primary school.

> I remember being given long division to do and they were not being explained very well and so when I gave the work to the teacher, they came back with red crosses all over it. And I felt bad and there was no any encouragement or kind patience to explain. So the method was not really explained very well or very patiently to a nervous young dreamy child. And the same with complicated multiplication. (R399, text-unit 11)

Thus, the data shows that the negative experiences of learning mathematics in primary schools were similar for both those who claimed to like and those who claimed to dislike mathematics. These experiences were characterised by rote learning, lack of clear explanations, lack of positive encouragement from their teachers, and repeated failure. It seems that what might have caused them to continue liking or disliking of mathematics was not primary mathematics but secondary school mathematics and higher level mathematics.

(v) Negative experiences of learning mathematics in secondary school

Only seven out of 36 of those who reported a liking of mathematics claimed that they had negative experiences of learning mathematics at secondary level. An administrative assistant recalled that "and I found A-level very different from the GCSE level. It became less applicable as I felt. I didn't feel it was so ... relevant to sort of, yes everyday life and ways that I can use it. So I guess it became less interesting in that way."(R121, text-unit 7)

Another mathematics teacher gave similar view:

> When I went to sixth form college to do mathematics. And I found that .. when it got to that stage, it was becoming more boring, it wasn't interesting...(R471, text-unit 19)

She went on to explain:

> I think there were too many formulas that you just have to learn. That didn't seem to mean anything. The aspect of mathematics at A-level that I did like was the mechanics. I enjoyed that because it actually mentioned forces and the application aspect."(R471, text-unit 21),

but "it was pure mathematics that I didn't like because it was too theoretical.(R471, text-unit 23)

Most of them found mathematical concepts at the higher level, especially at GCSE and A-level to have become more difficult to understand. They also felt these concepts not very relevant to life because they were too theoretical or there were too many formulae to remember.

Moreover, four of them complained that they did not enjoy mathematics at this level because their mathematics teachers "didn't make things very clear. And all of us felt that. Even though we were in the top group, she just read from the book. She didn't actually spend time to explain things very well. So it was just something that we had to do rather than something that we really interested in" (R205, text-unit 31). Some of them claimed that their mathematics teachers could not explain well or did not give enough attention to them. Others found them too strict or discouraging.

In contrast, out of 26 who stated that they disliked mathematics, 16 claimed to have negative experiences of learning mathematics when they were at lower secondary school, 12 claimed these occurred at GCSE or O-level while another two claimed to be at A-level. An ecologist who reported disliking mathematics described her high school mathematics experiences as follows:

> I think there was no particular moment, but I think it was more like a lot of, many lessons where I had to learn them but I came out not understanding a word of it being said by the teacher. More a prolonged frustration than any particular, I never...(R025, text-unit 49).

Almost all of them refer these negative experiences to the difficulty in understanding mathematics at these levels, especially at GCSE or A-levels. Some of them experienced repeated failures.

> I really struggled in secondary, especially when I got to O-level. (R153, text-unit 15) and

> I failed my mathematics at O-level, I got a U. And then I failed CSE three times then I passed it the fourth time, I suppose those were the worse moments in maths. (R153, text-unit 23)

In spite of struggling very hard to learn mathematics, two of these respondents claimed that they failed their O-level mathematics three times.

An elderly musician recalled a typical mathematics lesson of his as follows:

> For example, the teacher was explaining an equation on the board and he would say from this here and point to something and then said, and this here, and point to something, *We see that*! He will always say we see that, but I told myself, I do not

> see that! Or they will say, *it is obvious that*! And it was not obvious to me! …(R399, text unit 13, italic added to indicate increased in voice)

From his description, one could feel his frustration towards the insensitivity of his mathematics teacher. There were at least 12 of them who blamed their mathematics teachers for not explaining well.

However, not of all of them blamed these negative experiences on their mathematics teachers. A young barmaid commented that,

> "Doing mathematics in college? (Pause) I just found it hard. I just don't enjoy [hard] things, so I decided not to carry on with it.
>
> Interviewer: So you stop at college or A-level?
>
> R509: A-level.
>
> Interviewer: Did it have anything to do with your mathematics teacher?
>
> R509: No, it is just me. I just don't enjoy it." (R509, text-unit 15-19)

Another young sociology student and an older salesman expressed similar opinion:

> but I think, I don't know, my maths teacher weren't that bad. They, ... it's probably just the idea of maths more than what it actually is. (R338, text-unit 19)

> I don't think. I went to a number of schools and some of them were quite good schools. Hmm, not necessarily, I tend to think it was me, rather than them [mathematics teachers]. (R462, text-unit 23)

There were three respondents who blamed themselves, or the nature of mathematics for their negative experiences of learning mathematics in secondary school, rather than their mathematics teachers.

(vi) Negative experiences of learning mathematics at tertiary level

Two respondents who claimed to like mathematics regarded their bad experiences of learning mathematics happened at tertiary level. A university lecturer recalled:

> When I was at university, it was very different. There, I, …because it was a requirement of my psychology degree, that I studied statistics. And I didn't understand it at all. I found it enormously difficult for the best part of the year. ..." (R061, text-unit 26)

Another postgraduate student expressed similarly that:

> "I have been to many lectures in which I didn't understand anything and it is frustrating when you sit through a lecture which you would like to understand but you just don't. So, I mean, there have been many such lectures.
>
> Interviewer: Was it at university or at school?
>
> R191: No, not at school. At school level, I was on top of the materials. No, I do mean that later university level, beginning post graduate level that sort of things. (R191, text-unit 21-23)

At tertiary level, these people even found it harder and more difficult to understand the high level mathematical concepts and thus they sometimes felt frustrated and disappointed. Rather similar experiences of learning mathematics at tertiary level were also described by another respondent who reported a dislike of mathematics:

> We had to do statistics course and we had a lecturer that spoke, not English as we know it. He spoke with very long words. He won't use the normal English, or the day-to-day English. He used very ... jargon and abstract terms.
>
> Interviewer: Is he not English?
>
> R207: Yes, he is English. But, for example, when somebody asked him where is the escape key on the keyboard, he said look at upper left-hand quartile, not top left hand corner but upper left hand quartile. He didn't say things as simple as possible. And that wasn't just my feeling but was the whole class. (R207, text-unit 23-25)

However, she was referring more to the teaching style of her mathematics teacher.

In general, the data indicates that of the few who managed to get into the tertiary level and to study mathematics, many found mathematical concepts difficult to comprehend. In addition, if the teacher or lecturer explained the mathematics with jargon, or unfamiliar technical terms, it became even more difficult for them to understand.

Summary of experiences of learning mathematics in school

A. Those who claimed to like mathematics

Not all of those who claimed to like mathematics had positive experiences of learning mathematics from primary to secondary school. From the 36 interviewees who reported a liking of mathematics, only 14 of them claimed that they did not have any bad experiences of learning mathematics in school, and that they enjoyed learning mathematics throughout their primary and secondary school experience.

The majority of this group had experiences that included both positive and negative aspects. Some of them found primary and secondary level mathematics easy, fun and enjoyable up to 16, but found A-level mathematics difficult and less relevant to everyday life or to their interests. In contrast, some of this group found primary and lower secondary mathematics too basic and easy, but at higher level such as GCSE or A-level, they saw the beauty and challenge of mathematics. A few did not enjoy learning mathematics at all in schools but changed their views and attitudes towards mathematics after they started their careers.

The majority of this group related their positive experiences of learning mathematics to having encouraging and enthusiastic mathematics teachers. They claimed that their mathematics teachers were able to make mathematics easy and interesting to learn. However, a few of them credited their success to their own interest in the subject and their own mathematical abilities. They claimed that mathematics teachers did not play an important role in their enjoyment of the subject. On the other hand, a few of them stressed the importance of mathematics teacher as the sole agent that determines a student's interest in mathematics. According to them,

> Mathematics being such a boring subject, unless you got a good teacher, I mean, if the teacher didn't make the subject interesting, then I think any student can have a hard time doing that subject. (R316, text-unit 27)

These results suggest that prior experiences in learning mathematics, such as at primary and lower secondary level, might influence a person's motivation to continue to learn mathematics at higher level. However, for the respondents in this study, it is the higher levels such as at GCSE or A-level that are more important determining levels. At this level, those who previously liked mathematics might find it too difficult or irrelevant and change their attitudes towards it. Similarly, there are also those who began to appreciate the importance and the beauty of mathematics at these levels, normally with the help of inspiring mathematics teachers, and they changed their attitudes towards mathematics as a consequence. Thus, indirectly, these results suggest that secondary mathematics teachers might play a very important role in determining a student's interest or motivation in learning mathematics.

B. Those who claimed to dislike mathematics

Not all of those who claimed to dislike mathematics had unenjoyable or bad experiences of learning mathematics from primary to secondary school. Of the 26 interviewees who claimed to dislike mathematics, only six of them claimed that they never enjoyed learning mathematics in school at all.

Many of those who claimed to dislike mathematics did enjoy certain parts of their school mathematics experiences, at various different levels. For example, 9 of them claimed that they found primary level mathematics easy to understand and more fun-based, and consequently they quite enjoyed it. However, as they went through secondary mathematics especially to GCSE or O-level, they started to find mathematics too difficult to understand. Some of them struggled through but many of them felt frustrated and gave up mathematics at higher level as a result of this experience.

Almost half of them attributed their failure to their mathematics teachers. A few of them claimed that they were not taught properly as a child while others complained that their mathematics teachers did not explain well. Many of them also claimed that their mathematics teachers did not give them enough attention or encouragement.

Their experience of learning mathematics at school was characterised as didactic, non-interactive and with a lack of explanation. For example, one of them described his typical mathematics lesson at school as follows:

> We were just sitting in rows behind the desks and they (maths teachers) stood in the front and talked or wrote on the blackboard. Yes, they were going to do, I don't know, angles or matrices or algebra, or you know, all that sort of stuff. Then you have the exercise book to solve them up and then you have to get on with it. (R218, text unit 19)

Some of them claimed that they could not get along well with their mathematics teachers because they found their mathematics teachers sarcastic or did not have enough patience.

However, two of them did have experiences with mathematics teachers they perceived to be good at certain periods in their school life. A primary teacher trainee compared the difference in teaching between his 'amazing mathematics teacher' at GCSE level with his former mathematics teachers as follows:

> He did whole class teaching, he made sure that you understood what he went through in the textbook. That is when maths started to come alive. Because he made sure we understood before we were given a book to detail it out. Whereas before, it was just given the book and you get on with it, that's all. That was not the best way for me to learn, I think. I have a problem in the book. That problem was explained to me, then I can do the problem but the mathematics behind it was never explained. (R374, text-unit 11)

Nevertheless, due to their poor foundations and earlier lack of interest, they still failed to develop further interests in mathematics.

In this sample, four interviewees did not blame their mathematics teachers but blamed themselves for not doing well in mathematics and lacking interest in it.

VI. Possible factors of influence

Besides probing for the respondent's reason for liking or disliking mathematics and their mathematics learning experiences in school, I also asked the respondents to reflect on whether their images or views about mathematics had changed from their school years to the present. This second set of questions was aimed to explore the possible factors of influence on the respondents' images of mathematics. Some of these factors were found to be mathematics teachers, parents, peers, mass media and social perceptions and valuations of mathematics. Other related issues such as gender issues and beliefs about their own mathematical ability are also explored and discussed in the following sections.

(i) Mathematics teachers

Among the various factors quoted by the interview sample, mathematics teachers seem to be the most common factor that influences their liking and views of mathematics in school. Table 6.2 displays the degree of possible influence from mathematics teachers as reported by those who claimed to like mathematics and those who claimed to dislike mathematics. The different degrees are indicated by the terms (e.g., 'definitely', 'a lot' etc) as spoken by the interviewees themselves.

For those who claimed to like mathematics, five stressed that their images of mathematics were 'definitely' influenced by their mathematics teachers. 12 of them mentioned that their mathematics teachers had a great deal of influence on their liking or view of the subject, while only two denied any formative influence emanating from their mathematics teachers. Their experiences of mathematics teachers can be characterised by careful explanation and encouragement. They had found that their mathematics teachers were able to explain in such a way that it was easy for them to understand. Most of their mathematics teachers were also very encouraging and patient. One of them described his mathematics teacher's teaching as "he got the point over special, probably" (R328, text unit 33). While another interviewee described hers as "the best teacher that I had was good at trying to explain and would continue to try to explain because they knew I wanted to know…." (R133, text unit 28). Moreover, they found their mathematics teachers were able to make mathematics learning interesting and enjoyable. To many of them, this approach was important because "…maths being a boring subject, unless you got a good teacher, I mean, if the teacher didn't make the subject interesting, then I think any student can have a hard time doing that subject… (R293, text unit 27).

Nevertheless, a few of them also experienced mathematics teachers who did not explain well and some that were overly strict and sarcastic. They claimed that this kind of bad experience did influence them to some degree, but because of better experiences with more encouraging mathematics teachers later in their school careers, they were still motivated to learn mathematics.

There were two who denied any formative influence emanating from their mathematics teachers. One of them, a young mathematics student (R401) believed that he was born with the mathematical ability while the other, a young mathematics teacher (R 471) believed that her mother influenced her much more than her mathematics teacher.

Table 6.2: Degree of possible influence from mathematics teachers as reported by those who claimed to like mathematics and those who claimed to dislike mathematics

Degrees of influence reported	Those who claimed to like mathematics	Those who claimed to dislike mathematics
Definitely	5	2
A lot	12	11
Yes	6	2
Probably	3	6
Quite/not really	4	2

Not at all	2	0
Total	32	23

Therefore, the majority of those who reported a liking of mathematics stressed the importance of mathematics teachers in their images of mathematics and mathematics learning. According to them, teachers have a great influence, especially in mathematics, because mathematics is a subject that is difficult, boring at times and students can easily be put off. Only mathematics teachers who encourage you to learn, who give you individual attention, who explain well and whom you can get along well are the ones that shape their images of mathematics positively.

For example, one of them described how changing her mathematics teacher changed her views and her experience of learning mathematics, as follows:

> Because my first mathematics teacher, I didn't get along with her very well. I was quite frightened to ask her questions. And then I changed mathematics teacher and I went into another group because I was having problems with my first teacher. And things improved greatly then because she was very understanding and she explained a lot more to me. You know, she won't mind, she went over and over again. Again and again, I didn't feel like stupid because I could understand. Whereas before, like she went through it and she explained again and then I still didn't understand it. All I wanted to know is simple sorts of things, you know. I felt silly because I didn't understand. When I got the new teacher, she was very good. (R394, text unit 19-20)

On the other hand, for those who claimed to dislike mathematics, a similar trend can be observed. The majority of them (n=11) felt that the mathematics teacher has a lot of influence on their disliking and overall attitudes towards mathematics. Their experiences of mathematics teachers were characterised by a lack of explanation or poor explanations as well as a lack of patience. Many of them complained that

> …the teacher that I had didn't make much effort to make me understand it (mathematics) .. (R025, text unit 5)

> I had one that was sarcastic. She didn't have enough patience to wait as I need time to take things in, but I wasn't given the time to actually take things in. she didn't explain in great detail. (R153, text unit 19)

Similarly, a young nurse also described her experiences of mathematics teacher with strong feeling that:

> He [her mathematics teacher] hasn't got enough patience with you [her], he put you off any subject. I just think that I never have any poor teaching, [but] I just have nobody [who] really encouraged me. (R268, text-unit 25)

At least three of them claimed that they could not get along well with their mathematics teachers and consequently they disliked mathematics. Others complained that their mathematics teachers did not give them enough individual attention or give more attention to those who were better in mathematics. One senior student advisor felt that, "she (her mathematics teacher) concentrated very much on those who could do maths. And there was one girl in our form who was absolutely brilliant at it and she focused on her the whole time" (R115, text-unit 10).

About 10 of them complained that their mathematics teachers' teaching was very instrumental and not interesting and thus they were not motivated to learn mathematics. One student teacher described her typical mathematics lesson, as follows:

> What we used to do was just colour. Do this do that, you know. And no one ever told you why you do it. I never saw the needs to do it. Like trigonometry, I don't really care what the angle of the triangle is... (R284, text-unit 25)

Similarly, a retired teacher recalled his mathematics experiences in school and emphasised the importance of the teacher's explanations. He described with strong feelings:

> The thing that I can really remember about all this was absolutely failing with percentages. Until my rather glorious teacher said to me, "write it and divide it by bloody 100 and multiply by whatever percentage." It suddenly [came], after years of struggling, now I can do anything very quickly with percentages. This was one of those things that unless somebody else give you a cue for you to clip on to and explain to you. It is absolutely difficult for a child to understand. (R278, text-unit 29)

To conclude, both those who reported a liking of mathematics and those who reported a dislike of mathematics claimed that their mathematics teachers had a substantial

Table 6.3: A comparison of characteristics of mathematics teachers for those who claimed to like and those who claimed to dislike mathematics

♦	•
♦	•
♦	•
♦	•
♦	•
♦	•

influence on their images of mathematics. In addition, the data suggests that it was not necessarily a particular mathematics teacher that they had, sometimes they could have more than one mathematics teacher that influenced them. Sometimes they had a good experience with one teacher but a bad experience with another. However, the differences between these two groups seem to lie in the characteristics and personalities of their mathematics teachers, as well as their teaching approaches. Table 6.3 summarises and compares the different characteristics of mathematics teachers of the two groups.

(ii) Parents

Besides mathematics teachers, the second most common factor of influence is the home environment and parents. Among the parents, fathers seem to be more influential than mothers in the respondents' images of mathematics. Out of 36 who claimed to like mathematics, six of them quoted both parents, but ten of them quoted their fathers while three of them quoted their mothers as a significant factor of influence in their image or liking of mathematics. Only one of them quoted a sibling (her sister) as a possible factor of influence.

Analysis of the interview data shows that parental influence seems to be given in the form of moral support including encouragement and as a source of motivation, as a role model for a good mathematician; or through initial help, especially during primary school years. The majority of those who claimed to like mathematics felt that their parents encouraged them to do well in mathematics from the very initial stages of their school life. Most of them were helped by their parents in doing their homework. Some of them were given extra sums to do or mathematical games to play by their parents when they were in primary school.

Many of them believed that because their parents, especially their fathers, are good at mathematics they too should be good at it. Some of them described the influence of their father as follows:

> I mean he influenced me in the sense that I wanted to be as good as he was, at doing sums quickly and that sort of things…"(R293, text unit 29)

…I remembered my mum always saying that, he (his father) got the best degree in mathematics in Birmingham and something like that, so it is kind of encouragement that because we are kind of mathematics family. (R370, text unit 35)

Some of them felt that their parents were not really good at mathematics but because the parents valued mathematics for its importance in life, they too were influenced to do so.

...actually, mathematics is an important subject. They feel about the same about it, so they always tell me to respect the subject, just like English as well. (R316, text unit 59)

If by chance, we have home work or things like that, we were not only encouraged but made to sit down and do it before doing any other things else. My parents said that [mathematics] will be your priority and it is important for your later life. You must learn it now and if not, in later you will be left behind and that sort of thing. (R409, text unit 37)

On the other hand, among the 26 of those who claimed to dislike mathematics, only one of them quoted his parents, 2 of them quoted their fathers and one of them quoted his mother as factor of influence on their image of mathematics. The majority of them felt that their parents had no influence on them. Unlike those who claimed to like mathematics, this parental influence was not necessarily positive encouragement. One of them stated that her father was quite good at mathematics but he was a perfectionist and "he could make you feel very small, …if you didn't come up to his standard…" (R513, text unit 49). Therefore she felt discouraged. Moreover, she believed she was "sort of fearful person and I don't like, and I standing odd in an authority and that the man (her mathematics teacher) that I got on well with, he was gentle and kind. …" (R513, text-unit 35) in her earlier description of her experience with mathematics teacher.

Similarly, there was one respondent who had a lot of help from her father and said she would like to follow her father's footstep to be good at mathematics. When she found she wasn't, she felt frustrated.

Hmm. My dad …is very scientific orientated and he helped a lot actually when I had a very bad mathematics teacher. I think if it wasn't for him, I would have given up mathematics altogether. I think I would have got a lot worse without the help from home. (R025, text-unit 36)

…so because I always think myself to be more like my dad in mathematics. I am keener in following my dad's step. So,… I am kind of think that my dad is good at it and I think that is why I felt frustrated when I wasn't. (R025, text-unit 43)

Therefore, the results show that parental support and parents' image of mathematics are possible factors of influence on their children's image of mathematics. Those who claimed to like mathematics seem to get more support and encouragement from their parents than those who claimed to dislike mathematics.

(iii) Peers

Peer support seems to be another influential factor for some of the adult's images of mathematics. Out of the 36 who claimed to like mathematics, eight of them mentioned the influence of their peer groups. Those who claimed to like mathematics tended to mix with peers who also like mathematics or were good at mathematics. At primary school level, their peer groups were a source of competition while at higher level such as A-level, they acted as a support group. This is because "...collectively we sort of help to solve things and give encouragement to each other" (R328, text unit 57).

On the other hand, out of the 26 who claimed to dislike mathematics, six of them mentioned peer group as the possible influential factors on their attitudes to and views about mathematics. In contrast with the former group, they tended to mix with school friends who disliked mathematics or who were anti-mathematics. One of them claimed that, "...we just all thought the same thing about maths. Most school kids think that maths is dull but there is always an occasional one. I think that is only thing that influences really, to be honest" (R338, text unit 46). There was one exception whose group of friends were mostly good at mathematics. However, they made her feel inferior, as she described in emotional terms: "But they kind of emphasised that mathematics was something very difficult and not possible for me" (R374, text unit 27).

Thus, the results show that peers can also influence some adult's image of mathematics. This influence could be either positive as in the form of encouragement and a source of competition or it could be negative as it might promote feelings of inferiority or inadequacy in mathematics.

(iv) Mass media

Mass media such as television programmes and reference books can also have considerable influence on people's image of mathematics. In this study, 8 out of 36 of those who claimed to like mathematics reported that they like to watch mathematical programmes on television such as 'Countdown' for its problem solving, while some were fascinated with the mathematical findings and applications of programmes such as the documentary 'Fermat's last Theorem'. This documentary was shown on television during the period of data collection, and two respondents mentioned that they watched this programme with interest.

On the hand, although only 4 out 26 of those who claimed to dislike mathematics quoted the mass media as an influence, several of them seem to have changed their views about mathematics after watching mathematics-related programmes on TV or reading books on mathematics. For example, three of them claimed that after reading "a book that made mathematics much more interesting." (R153, text unit 27) or "a book which is quite a lot on maths…it might have influenced my view. It made me more sympathetic to the subject..." because he recognised that "there are essentially unavoidable problems in maths. It can't be avoided as much as I like" (R283, text unit 47-49).

Therefore, these results suggest that public mass media including television programmes, on mathematics and newspaper articles and books can help to promote public understanding of mathematics and also a better public image of mathematics. Good reference books on mathematics may also play a part in changing the public's views of mathematics.

(v) Social stereotypes and valuations of mathematics

The majority of the respondents who claimed to like mathematics denied that their views about mathematics were influenced by the social stereotypes and valuations of mathematics. According to them, the social stereotypes are having very negative views about mathematics such as 'mathematics is difficult and boring' and 'most people hate mathematics'. Therefore they actually hold views opposite from these social stereotypes, in the sense that they like mathematics, and they also find mathematics interesting.

However, two of them agreed that their views about mathematics were influenced to a certain degree by social stereotypes and valuations of mathematics. They argued that "society influences you because it makes it important that you understand, yes, I mean if you don't understand mathematics then you won't get very far, do you?" (R495, text unit 51). As importance of mathematics is widely accepted in society, they too see the positive value of mathematics.

Interestingly, no one from those who reported a dislike of mathematics mentioned any influence from social stereotypes and valuations of mathematics.

(vi) Own interest

A young student majoring in sport science who expressed liking mathematics believed that, "I think it is completely myself. My mind sort of drives me to mathematical or any other forms of work" (R120, text-unit 29). Another postgraduate student majoring in mathematics also support this view that, "I think the interest came more from me-- from myself and I can't explain why. Because it wasn't my parents" (R191, text-unit 33). Thus, the data shows ten out of 36 of those who claimed to like mathematics believed that they have positive view about mathematics were more because of their own self-interest and self-motivation, rather than external factors such as mathematics teachers or parents.

Similarly, seven out of the sample of 26 who claimed to dislike mathematics did not blame their mathematics teachers for their negative attitudes towards mathematics. Instead they believed that they themselves were to be responsible. They made statements like: "it is just me, I just don't enjoy it" (R509, text-unit 19) and "I tend to think it was me, rather than them (the mathematics teachers)" (R462, text-unit 23). These interviewees show a lack of interest in mathematics and at least two of them believed that they lack the mathematical ability or aptitude. One of them added that, "I think it is an intellect thing. There is little bit missing in my brain that it doesn't pick up on that, and it switches it off" (R462, text-unit 25).

In brief, these results suggest that some respondents from both groups, who claimed to like mathematics and those who claimed to dislike mathematics, believed that their own interest and attitudes towards mathematics are also important contributing factors for their images of mathematics.

(vii) Other possible factors of influence

Besides the six factors listed above, other possible factors of influence were given by some of the sample including course of study and career needs.

Attending higher level courses in mathematics such as A-level or university mathematics courses or additional training such as teacher training or in-service courses related to mathematics seem to promote a better understanding of mathematics and thus changed some of the sample's views about mathematics. This was especially so for those who reported a dislike of mathematics, because they claimed to have gained better understanding through working with mathematics. One of them found that although he still did not like mathematics very much, after taking science courses at A-level and information technology at university level that involved mathematics, he said that, "...because I have to do it, then I don't mind and I like it. Instead of, if it didn't really involve maths then it will be something different and it will be hard for me to understand" (R017, text unit 49).

A few of the sample also claimed that they changed their view about mathematics to be more positive after the experience of working. This is because they need to use mathematics in their careers and thus see the practical uses and application of mathematics. Only one of them mentioned that his view about mathematics changed because of interaction with his colleagues at work.

Frequent failure in examinations also led a few of the sample to lose their self-confidence in mathematics and thus to have negative attitudes towards mathematics. Two of the sample quoted that they failed mathematics at O-level three times. This kind of bad experience, they claimed, has greatly influenced their attitudes to mathematics.

VII. Other Issues

Suggestions for better mathematics learning

The respondents were also asked to give suggestions for the improvement of the mathematics learning experience. Although the majority of them stated that they are not in education, or they have long been out of school and thus are unable to give many suggestions, nevertheless, almost half (25 out of 62) gave some forms of suggestions for improving mathematics learning.

Those who claimed to like mathematics tended to stress the importance of removing the anxiety or the negative image of mathematics as 'difficult' or 'only for the clever ones'.

They suggested that mathematics teachers should try to motivate and build up the self-confidence of pupils and convince them that everybody is able to be good at mathematics. One of them also suggested that we should admit that mathematics is difficult but then prepare students to take it on as a challenge.

In addition, several of the respondents stressed the importance of relating mathematics to daily life experiences or activities and teaching it as a practical tool. They also suggested that as an effective teaching strategy, students should be allowed to explore and solve problems themselves. At least two of the respondents made the critical remark that the mathematics teacher should "not (be) somebody who just stand there and lectures" (R547, text unit 71). But that instead they should "teach from the very beginning, how it can be applied to the real world and to see that it excites the teacher as well" (R547, text unit 69).

For those who claimed to dislike mathematics, they tended to emphasise making mathematics interesting and fun by using games. This is because of their view that by making it more fun and " gets the students interested and they want to learn it, instead of feeling that they *have* to learn it. …I think if you get that attitude from an early age, then I think you go along and you do it and you don't mind doing that" (R496, text unit 67). They also stressed the importance of understanding and through step by step explanations, and "telling them, you know, where and how to get certain formula and problems, and then set them off for their own problems …" (R374, text unit 23). Other suggestions included relating mathematics to practical activities and exploiting the fact that mathematics is inter-linked with many other subjects.

In conclusion, I notice that suggestions from both groups (those who stated that they liked and those who stated they disliked mathematics) were similar. Both tend to emphasise the importance of clear explanation, interesting and enjoyable mathematics lessons, as well as the relevance of mathematics in daily life.

Gender issues

Although the majority of the respondents interviewed agreed that society tends to view mathematics as a male subject, they did not agree that there is a gender difference in mathematical ability. Only three out of the 62 interviewees claimed that they were influenced to some extent by this societal view, and consequently that they believed that boys are better in mathematics than girls. As one of them argued, being female herself, she believed that it is acceptable for females not to be as good in mathematics as are males. However, this issue elicited a very different response from another female respondent who remarked that:

> I think that sort of not girl subject at A-level that may have kept me going and it was one of the reasons that I took it (maths). (R121, text-unit 39)

However, another male respondent stated his belief that:

> men have slightly more enquiring and logical brains than women. I think good mathematicians tend to be male rather than females, like men tend to be better cooks, ha! Ha! (R495, text-unit 53).

The results thus suggest that the belief that mathematics as a male dominant subject seems still to be held by some respondents in this study, although its influence was not necessarily negative for all of them.

Beliefs about mathematical ability

When the respondents were asked if they thought that some people are just better in mathematics than others, 95.4% of them agreed (reported in Chapter 5, section IV.1). However, when they were interviewed about the same question, three types of responses were given.

For those who claimed to like mathematics, four of them strongly expressed the belief that some people are "born with the natural mathematical ability" (R495, text unit 31) and "either you have it or you haven't" (R043, text unit 35). Some of them called this ability "aptitude" (R121, text unit 45) while others as having a "mathematical brain" (R409, text unit 49). Nevertheless, they believe that besides mathematical ability, one also needs to have motivation and encouragement from both teachers and parents.

However, two others who liked mathematics strongly disagreed with the view that one needs to have inborn mathematical ability to be good at mathematics. They believed that "everyone can be good at it" (R370, text unit 39) because the more important factors are "the right teaching and the right attitude" (R370, text unit 39), although "for some people, it might take longer time to get interested than the others but at the end of the day, I think everyone can be just as good" (R370, text unit 39).

There were also a few of them who believed that everyone can be good at mathematics but obviously "some people will find it easier" (R158, text unit 23). It also "depends on how much you are coached to learn, and also who is teaching it and who is explaining it."(R165, text unit 21) Therefore, all of them seem to stress the importance of external factors such as mathematics teachers and parents.

Those who expressed a dislike of mathematics gave similar responses to this issue. Four of them agreed that some people are just better in mathematics than others because they have "natural skill with numbers" (R218, text unit 27). They believed that "some got the ability and some don't" (R267, text unit 49). In addition, one of them believed that his lack of interest in mathematics is because "there is a little bit missing in my brain that it doesn't pick up on that. And it switches it off" (R462, text unit 25).

There were three interviewees who claimed to dislike mathematics agreed partly that some people have better mathematical ability than others. They believed that "everyone will probably manage it if they were taught properly in school" (R284, text unit 43), and it is more "a nature-nurture thing" (R399, text unit 35) which means a balance between natural aptitude and appropriate experiences.

Therefore, the results indicate that both who claimed to like mathematics and those who claimed to dislike mathematics seem to hold similar beliefs about mathematical ability. The majority of them believe that one needs to have mathematical ability to be good at mathematics. However, many of them also emphasise the importance of external factors such as mathematics teachers and parents.

VIII. Comparison between variables

In previous sections, I attempted to analyse the data in terms of reasons for liking and disliking mathematics, images of mathematics and learning mathematics, as well as the possible factors of influence. I also made a comparison between those who expressed liking and those expressed a disliking of mathematics. Striking differences were found in their reasons for liking and disliking mathematics, but very similar images of mathematics and learning mathematics were given. With regards to possible factors of influence, the mathematics teacher was the most significant factor for both groups, followed by their parents, their peers and their own interest in mathematics.

As the interview sample also comprises subgroups of different gender, age and occupation, below I attempt to further explore the data by making comparisons among these subgroups. I aimed to explore whether there is any general trend or any significant differences can be discerned among these subgroups with regards to their reasons for liking or disliking mathematics; their images of mathematics and learning mathematics; as well as the possible factors of influence. In view of the sample size of 62, which is too large for qualitative analysis. I decided to use a quantitative approach, using frequency of occurrence and the ranking of these frequencies to display and compare any general trends among the different subgroups. The results of these analysis and comparisons were displayed in Table K.1 to K.4 in Appendix K.

Comparison between genders

Reasons for liking or disliking mathematics

A trend is observed shared by both the male and female respondents in their reasons for liking. However, there is a slight different in the ranking of the most common reasons for disliking mathematics between males and females. The males tended to link to external factors such as blaming their mathematics teacher:

> I was taught badly so I don't easily understand it very much. (R399, text-unit 3).

Whereas the females tended to give their reason for disliking mathematics to be associated with strong negative feelings, as well as their own lack of ability in mathematics:

> I don't have a natural talent for it [mathematics]. (R207, text-unit 3)

Images of mathematics

Images of mathematics given by both genders seem to be very similar in ranking. Both groups shared the most commonly held images of mathematics as a practical tool. This ranking is followed by mathematics providing a certainty in answers; mathematics as made up of numbers, equations and formulae (symbolism); and mathematics as logical thinking. The similarities in images exhibited by both group reconfirms the earlier result of stage one (see Chapter 5 Section III.4.3) that there was no significant differences between genders on their images of mathematics.

Possible factors of influence

Comparing the genders, both males and females listed five similar factors of formative influence. These factors include mathematics teachers; parents; own interest; peers, and social stereotypes and valuations of mathematics. However, more males than females believed that parents have more influence than peers, and more than social stereotypes and valuations of mathematics. This result possibly shows that males might have received more encouragement and support from their parents while the females were more easily influenced by their peers, as well as by social stereotypes and valuations of mathematics.

Comparison among age groups

Reasons for liking mathematics

In terms of reasons for liking, the younger age group (17-20 years old) seems to display slight differences from the other age groups. They claimed that they like mathematics because they view mathematics as a challenge, and mathematics can give them a sense of satisfaction. However, two older age groups (over 30 years old) claimed that they like mathematics because they are confident with mathematics and they find mathematics useful in their daily life and their work. Nevertheless, across all age groups, many of them claimed to like mathematics because they like the problem solving aspect as well as the logical nature of mathematics.

Reasons for disliking mathematics

The younger generation (below 30 years old) claimed to dislike mathematics because they lack self-confidence in mathematics. They tend to believe that mathematics is only for the clever ones. Consequently, they tend to associate mathematics with strong negative reactions of feeling such as 'cold' and 'boredom'. On the other hand, the older generation (those over 30s) tend to believe that if they were not taught properly as a child, it was their teachers' fault. They too found mathematics difficult to understand, and some of them associate mathematics with strong negative feelings.

Images of mathematics

It was a surprise to notice that images of mathematics given by the youngest age group (17-20) was very similar to that given by the oldest age group (aged 50 and above). For both groups, the two most common categories of image of mathematics were given as a practical tool, and that mathematics provides certainty in answers. However, on the whole, there was no striking difference in the images of mathematics given across all age groups. This result reconfirms the earlier finding of this study on comparison among age groups (see Chapter 5 Section III.4.3).

Possible factors of influence

Comparing the different age groups, one striking difference was observed in the most common factors of influence. Only the youngest age group listed their own interests in or attitude to mathematics as the most common factor of influence, whereas the other three groups listed the mathematics teacher as the most common factor. In addition, the peer group seems to be a more influential factor than parents for the younger generation (below 30 years old). Interestingly, the reverse trend holds for the older respondents (those above 30 years old). The three common factors of influence across all age groups are mathematics teachers, parents and own interest in the subject. In brief, the younger age groups believed that they are influenced by their own interest in mathematics and their peers, whereas the older age groups worried more about the social stereotypes and valuations of mathematics, including those of their parents and mathematics teachers.

Comparison Among different occupational groupings

Reasons for liking mathematics

Some interesting results were found when the reasons for liking mathematics were compared among the different occupational groupings. Firstly, even though the mathematics teachers from the interview sample gave similar reasons for liking mathematics, it is interesting to notice that their most common reason for liking mathematics was listed as the beauty of mathematics. However, this reason was hardly ever given by any other occupational groupings (the only exception being two from the professionals group and two from the skilled worker group).

Secondly, the mathematics students tended to view mathematics as a challenge, whereas no non-mathematics students shared this as their reasons for liking mathematics. In contrast, the non-mathematics students tended to emphasise the feelings of satisfaction, and the power of certainty of mathematics as their reasons for liking it.

Nevertheless, all the occupational groupings claimed that they like mathematics because they like the problem solving aspect of mathematics. Besides this, another common reason for liking given across all occupational groupings was that they believe that they are good at mathematics, and they find mathematics applicable in their daily life or their work.

Reasons for disliking mathematics

As occupational grouping is closely related to age group, I expected to observe some similar trends in reasons for dislike among certain group of them. For example, both mathematics students and non-mathematics students belong to the youngest age group (age 17-20), their most common reason for disliking mathematics was as expected, to have related to the belief that 'mathematics is only for the clever ones'. Perhaps it was not a surprise that the ranking of reasons for disliking mathematics given by both groups of students was similar too.

Likewise, of those who held this view, the professionals and the managerial groups gave similar reasons for disliking mathematics. Both groups' most common listed reason for disliking mathematics was the perceived failure of their mathematics teachers in not teaching them properly at an early age. However, this reason is also given by all occupational groupings except the mathematics teachers. It is reasonable to expect that no mathematics teacher should dislikes mathematics, or else, they should not have chosen to become mathematics teachers.

Images of mathematics

A rather similar pattern of image of mathematics was given by all the occupational groupings. But there is one interesting difference between those with higher mathematics qualifications (e.g., mathematics teachers, mathematics students and the professionals) from those with lower mathematics qualification (e.g., non-mathematics students, skilled and unskilled workers). The images of mathematics of the former seem to be dominated by the 'power of certainty and objectivity' of mathematics whereas the latter group seems to view mathematics as 'a practical tool'.

Possible factors of influence

A similar trend was observed in the list of possible factors of influence given by the different occupational groupings. The five most common factors of influence were: mathematics teachers; parents; peers; own interests in mathematics; and social stereotypes and valuations of mathematics. Among these factors, the mathematics teacher was listed as the most common influence. The other four factors vary in their degrees of common occurrence among the different occupational groupings. However, it is interesting to notice that three groups (i.e., mathematics teachers, non-mathematics teachers and mathematics students) were more influenced by their course of study than were the other occupational subgroups. The course of study referred to was usually teacher training courses or higher level courses in mathematics (such as A-level and higher). Thus, these results suggest that further study in mathematics might have some influence on a person's image of mathematics. It might not necessarily be a change towards a more positive image of mathematics, but it certainly helps to widen their knowledge and the scope of their views of mathematics, in turn these elements of knowledge might have some impact on their images of mathematics.

Another interesting fact is that both the student groups (mathematics and non-mathematics) tend to believe that their own interests and motivation in mathematics were much more important factors of influence than the influences of their parents. In contrast, other occupational subgroups seem to consider parents and peers as more important factors of influence.

To sum up, the comparisons made between different genders, age and occupational groupings thus suggest that there seems to have little differences in the reasons given for liking mathematics, and the images of mathematics given across all these variable subgroups. However, gender, age and occupational differences seem to have some impact on the reasons given for disliking mathematics and the ranking of the factors of influence. While the male respondents tend to blame their mathematics teachers, the female respondents tend to blame themselves for lack of mathematical ability as their negative attitudes towards mathematics. The younger generation (particularly, the young people of aged 17-20 years old) and the student groups tend to blame themselves for lack of mathematical ability, whereas the older generation and the higher occupational subgroups tend to blame on others (such as parents and mathematics teachers).

IX. Six exemplar cases

Comparison in terms of gender, age and occupational groupings above seems to show that there is no typical case of image of mathematics or learning mathematics among these interviewees. However, significant differences exist between reasons for liking and disliking mathematics as well as possible factor of influence. Therefore, it is interesting and illuminating to study in detail some exemplar cases.

I have chosen the following six cases with the aim of maximising the comparisons and contrasting the different cases. As explained above I am aware that it is not possible for me to select any typical cases from my sample. Thus, these cases are chosen based on the following criteria:

a) reported liking and disliking to examine closely the differences and similarities between reasons for liking and disliking mathematics, as perceived by them;

b) the notion of 'maths is difficult' seems significant among both those who claimed to like mathematics and those who claimed to dislike mathematics, but they seem to deal with it differently. Therefore, these cases are chosen to reflect how differently they conceptualise the notion of difficulty, as well as the way they overcome it.

c) there seem to be significant differences between the observed factors of influence for those who claimed to like mathematics and those who claimed to dislike mathematics. Thus, it might be helpful to examine further how these different factors could possibly influence these groups of respondents. Cases are chosen with the aim of illuminating this further.

d) the difference between mathematical 'experts' in mathematics and 'lay persons' might also be worth examination. Here, I refer the term, mathematical 'experts' to those who have at least tertiary degrees in mathematics and their careers are mathematics-related (e.g., mathematics teacher and students, or mathematicians), while the term, 'lay persons' was referred to those who have no direct involvement in mathematics (e.g. non-mathematics students). Neither all 'experts' nor 'lay persons' like or dislike mathematics. In fact, most 'experts' like mathematics while most 'lay persons' dislike mathematics. Therefore, it will be interesting to explore what are the attractions or negative features of mathematics for both of them.

Case 1: (R191)

Profile: *A postgraduate student in pure mathematics *likes mathematics
* Age between 21-30 years old * Male

R191 likes mathematics because "there are pleasing patterns, one can find attractive solutions to problems" (text-unit 3). He especially appreciates the beauty of mathematical problems that have exact solutions and elegant proofs. Hence, he gave his image of mathematics as "difficult, at its best it is highly elegant -- even great art". To him, mathematics is a great art, and one of beauty even though one can not deny that mathematics is difficult to understand. Like many other respondents, he perceives mathematics as a subject that is difficult to understand. However, he added, "when you have struggled to understand something, and eventually you realised how it works and why it works, … that is all very satisfying" (text-unit 15). Therefore, one notices that he perceives the notion of 'difficulty' in mathematics similarly to how others perceive it, that is mathematics is difficult to comprehend. But then, it is this struggle to work hard to achieve the solution that he takes as a big challenge. He also experiences great satisfaction and felt very rewarded from this process of understanding. He described his image of learning mathematics as "mostly frustrating, with occasional insights/revelations that make it all worthwhile" in the questionnaire.

During his primary and secondary school, and even at the undergraduate level, he sailed through his mathematics studies smoothly and easily. It was only when he started to do his postgraduate study in mathematics that he experienced some difficult times. For example, he quoted that, "I have been to many lectures in which I didn't understand anything and it is frustrating when you sit through a lecture which you would like to understand but you just don't"(text-unit 21). Nevertheless, these bad experiences did not deter him from taking up mathematics. Instead they pushed him to work harder and to achieve greater satisfaction when he finally understand them.

He believed that his success in mathematics is mainly the result of his own interest. He also admits that his mathematics teacher especially the one he had in his middle school might have some influence. He found that most of his mathematics teachers paid special attentions to him by giving him extra or more challenging questions to practise. This is because his teachers knew that, "the methods, the similar things, [that] what she was teaching anybody else was quite...was not challenging enough for me. So she gave me a lot more to do to further my interest" (text-unit 31). He did not believe that his parents or his peers have any influence on him. Thus, the two main factors of influence for him are his own interest and his mathematics teachers.

His image of mathematics seems to be dominated by his notion of 'difficulty' and the 'satisfaction of working through it'. This notion was emphasised in his suggestion for better mathematics teaching. He asserts that,

> I am quite concerned that there seems to be a tendency to try to make it more interesting at the expense of throwing out what is difficult. And mathematics is difficult and one has to prepare to work with it. There is no other way round. I find it if I spent the week not working hard, I won't get any progress and I get frustrated. The progress comes through working hard especially for mathematics. So I think one has to be make it motivated, [but] children have to also put [effort] into their work. (text-unit 41)

This is an interesting case because it shows that even the potential mathematician (e.g. R191), found mathematics 'difficult' but he too emphasises the importance of taking this difficulty as a challenge and work hard to enjoy the satisfaction of success at the end.

Case 2: R120

Profile: *A sport science student *likes mathematics
** Age between 17-20 years old* ** Female*

R120 likes mathematics because of "the fact that there is always a right answer" (text-unit 3). She believes that "you can use a number of different ways to get the right answer" (text-unit 5) and she felt certain and confident when she is able to come out with the right answer. Consequently, she described her image of mathematics as "a challenging subject when grasped on whatever level, can be very intellectually satisfying". She explained that, "If I get it quite difficult and then you know, I worked very hard at it and I got to get the grade at the end of the day "(text-unit 11), and she felt that, "once I can get that, I find it is really satisfying" (text-unit 13). Similar to many other people, she also conceptualises mathematics as 'difficult' but she is willing to work hard and it is the satisfaction of getting the right answer that motivated her to go forward. This image is reflected in her image of learning mathematics too. She gave an interesting metaphor for her image of learning mathematics as, "trying to find the correct keys to unlock the doors along a never ending corridor, finding rewards at each one when unlocked".

Her experience of mathematics learning was enjoyable and fun during her primary school. Even though she found secondary mathematics was harder and more serious, she found enjoyable, rewarding and challenging; it is "fun because you can do it and [you know that] it is quite hard. You get enjoyment after that way" (text-unit 21).

She attributed her interest in mathematics mainly to her own self. She expressed this as follows: "I think it is completely myself. My mind sort of drives me to mathematical or any other form of work" (text-unit 29). Nevertheless, she also believed that her mathematics teacher could have some influence on her. She found her mathematics teacher "quite sexist" and "sarcastic" and with that she wanted "to be able to prove him wrong" (text-unit 33), so she pushed herself to work harder in mathematics. She also acknowledged that her classmates influenced her interest in mathematics because she treated them as competitors.

This is an interesting case because the mathematics teacher was not playing an encouraging role in the usual way but instead adopted an antagonistic approach. Did this happen to her because of her strong personality or because she is a female? It is beyond the scope of this study to make offer any conclusive findings on this subject's remark. Further research into this phenomenon is needed to gain better insight into the possible mechanism.

Case 3: R328

Profile: *A surveyor *likes mathematics
** Age between 31-50 years old* ** Male*

R328 gave his reason for liking mathematics as the fact that mathematics is a practical tool for him. He needs to use quite a lot of calculations such as the basic calculation of volumes, areas and other measurement in his daily work. As a result, his image of mathematics is "calculating". He viewed mathematics as mainly calculation of numbers and figures. He found learning mathematics "fun and interesting". He particularly liked to learn algebra because "it can be quite difficult to learn and so I quite enjoy that sort of thing, really" (text-unit 19). Like many others, he also perceived certain part of mathematics as 'difficult' but again he took this difficulty to make up the challenges that he enjoyed the most.

He did not enjoy his primary school mathematics very much because he found it difficult to grasp the concepts as compared to the other subjects that he had in school. In fact, his interest in mathematics changed greatly when he met with an encouraging mathematics teacher at his upper secondary school. He confessed that, "one of our teachers that we had years ago, who took us for mathematics was very good at it (mathematics). So, I mean, for you to pick up fairly easily. It might have affected me really" (text-unit 27). He described his mathematics teacher's teaching as "he got the point over special, probably" (text-unit 33). What he emphasised was that his mathematics teacher explained well and also in an interesting way, and consequently he found mathematics easy to understand.

He believed that his parents, especially his father, could have influenced his view of mathematics. Although his father was not excellent in mathematics himself, he used to coach him and help him a lot in his early days. He also received much help and encouragement from his school friends. He explained that, "obviously collectively we sort of help to solve things and give encouragement to each other" (text-unit 57). Therefore, R328 seem to receive three possible source of influence, namely, the mathematics teachers, his father and his peers.

To conclude, these three cases illustrate that many of those who claimed to like mathematics also perceived mathematics as 'difficult' but then they took the 'difficulty' as challenges. They are willing to work hard and put a lot of efforts into it. It is the satisfaction of finding the right answer or solving the problem that motivated them further. Most of them seem to attribute the possible factors of influence as based on their own interest in mathematics, their mathematics teachers, their parents and their peers.

Case 4: R548

Profile: *A postgraduate research student in Sport Science *dislikes mathematics

** Age between 21-30 years old* ** male*

R548 dislikes mathematics because he believes that he is "not very good at it. And other people who are better than me, which I think [they] really like [mathematics]" (text-unit 3). He tends to compare his ability with other people and he believed that he was not as good as others in mathematics.

He viewed mathematics as "something that need to be done" and he explained that mathematics "is a necessity, yes, rather than something that could be enjoyable" (text-unit 31). As he could not avoid using mathematics such as statistics in his present research, he actually expressed strong negative emotion that he "hate statistics" (text-unit 51) and "found statistics disgusting" (text-unit 49).

He portrayed his image of learning mathematics as a painful experience like, "having hot pokers shoved in your eyes" in the questionnaire. He explained that, "it is kind of mathematics that I don't really enjoy very much. It is a painful experience because I should be better at it than I am." (text-unit 33). Earlier on, he described his mathematics learning experience at primary school as enjoyable and fun-based because he was allowed "to use marbles and the teacher used to make up names of the numbers and things like that and it was usually more fun" (text-unit 7). Even during his lower secondary school, he was "used to enjoy mathematics because I was on the top set and we did occasionally still a little bit more fun-based. But over the year, maths become harder and harder. " (text-unit 11). Then at the start of his GCSE level, he felt disheartened when he was advised to take the lower level examination by his mathematics teacher. He did not blame his mathematics teacher for this, but again he tended to compare himself with others and believed that he was not as good as others in mathematics. Consequently, this realisation that "I wasn't as good as I thought I was" (text-unit 17) might have made him to start to dislike mathematics.

Besides the failures in his past experience, he also attributed his reason for disliking mathematics to the nature of mathematics. He found mathematics as having absolute truth, "dry", "not questionable" and "cannot be discussed" (text-unit 37). He prefers subjects like English and History where he can argue and put his "own thought into" them (text-unit 43).

In terms of parental influence, he believed that, "perhaps I am more like my mother because she is more creative while my father is very mathematical" (text-unit 47). He believed that his parents could have some influence on him in his early years of school but he was not sure whether they have any genetic influence on him.

In comparison between R191 (Case 1) and R548: (Case 4), I notice that both of them are postgraduate research students and both of them were also top students at their early years of schooling. In addition, both of them found mathematics getting difficult at the later stage. However, while R191 took up the 'difficulty' of mathematics as challenges and succeeded, R548 felt disgraced put off by his failures and believed that mathematics was only for the clever ones and hence he was not as good as the others.

Case 5: R218

Profile: *A mental health professional *dislikes mathematics
** Age 31-50 years old* ** female*

R462 claims to dislike mathematics because she found mathematical concepts difficult to understand and also irrelevant to her life. She can handle and understand the relevance of day-to-day mathematics such as the calculation of household budget. However, "when it gets away from reality, from my reality, it doesn't have any direct relevance to me, I have no interest." (text-unit 3) and she found these concepts difficult to understand too.

Her image of mathematics was "frightening and cold" because these were her feelings when she recalled her day at school. She blamed that on her mathematics teachers because "mathematics was never taught to us, you know, in a thoughtful way. It was always difficult" (text-unit 7). She stressed that "I think I hardly have any respect for my mathematics teachers because I don't think they were teaching me in a way that I could understand, why were they telling me this, what relevance does it have. What is so important about this. There were a lot of theories that you have to learn but you could not see why you have to know it" (text-unit 9). She believed that her mathematics teachers did not explain well and she could not see the relevance of learning mathematics at all.

As a result, she developed her image of learning mathematics as "climbing a steep hill". She found learning mathematics "was all suffering and so little enjoyment" (text-unit 15). Even though sometimes she found satisfaction when she found the right answer. Most of the time she found she was just following the formula without any deep understanding of what it is all about.

Besides mathematics teachers, she also believed that she might have lacked "the natural skill with number" (text-unit 27) that some people have, so that she is not good at mathematics. She prefers words to numbers because she felt "words [are] nice and warm and comforting and reassuring but numbers are cold" (text-unit 29).

In brief, Case 5 shows an exemplar case of someone who dislikes mathematics because she cannot see the relevance of mathematics in her daily life. She found mathematics difficult but she did not take it as challenges. Instead, she puts her blame to her mathematics teacher for not explaining well and not giving enough encouragement to her. Indirectly, case 5 implies the important role of mathematics teacher in a student's view of mathematics.

Case 6: R268

Profile: *A nurse *dislikes mathematics
** Age between 21-30 years old* **female*

R268 disliked mathematics because she found mathematics "difficult especially when people are asking for answer for the sum" (text-unit 3). She felt nervous and embarrassed because she was not good at doing mental arithmetic. Thus, she described her image of mathematics as "difficult" in the questionnaire.

She described her image of learning mathematics as like "being stuck in a bus queue". She gave her explanation with laughter that, "I just get really irritable as you can't even see what is in front of you" (text-unit 17) and "you just got to stand there and fiddle" (text-unit 19). She stressed that unlike her friends, she used to struggle very hard by doing extra homework in order to cope with her mathematics. In spite of this, she still failed her O-level examinations three times.

She enjoyed her primary school mathematics because it was more fun. But she found learning secondary school mathematics boring and difficult. She blamed this on her mathematics teacher for not giving her enough encouragement and for not having enough patience. Even though when she was 14 years old, she had a good mathematics teacher who tried to help her, but she still failed her examination. Again, she blamed that on her mathematics teacher and believed that if "he [her mathematics teacher] has more interesting teaching methods" and "if it [mathematics] has been [made] more clear to me, because you can't just learnt it by remember, can you?" (text-unit 27), she would have learnt mathematics better.

Besides her mathematics teacher, she also believed that the other two possible factors of influence on her view about mathematics were her parents and her cousin. Her mother was good at mathematics but her father was not. Although her mother tried to explain to her patiently when she was young, she believed she did not inherit her mother's mathematical ability. Instead, she believed that she inherited more of her father's interest such as in art and music. Moreover, she found her cousin daunting to follow because "he got a talent in mathematics" (text-unit 39).

In addition, she viewed mathematics as "more scientific than English, which is quite creative and artistic. I always thought that people who are very mathematical are scientific, and precise and logical. But I am not logical at all" (text-unit 55). Therefore she believed that because she is a more artistic person, she is not good at mathematics.

She also strongly believed in "boys being a bit quicker at it [mathematics] than girls" (text-unit 51) because when she was at school, she found "boys used to grasp it much quicker" (text-unit 53). She also related this gender difference to her view that mathematics is a scientific subject that the boys are better at. According to her opinion, girls are better at artistic subjects such as English because boys tend to be less creative than girls are.

She confessed that she has changed her attitudes towards mathematics after these years. She still find mathematics difficult but now she believed that, "I think now, if I practised it, I could be good at it" (text-unit 71). She felt that mathematics teachers were responsible when she was in school but now she is an adult, she should be responsible for herself.

X. Two special cases from age group 17-20

As the young people group (aged between 17-20) displayed the most negative images of mathematics as compared to the other subgroups, it might be interesting and worthwhile to investigate in detail two different cases from this group.

Case 7: R370

Profile: *A mathematics student *likes mathematics
** Age between 17-20 years old* **male*

R370 claimed to like mathematics because he liked the challenge of solving mathematical problems. He felt depressed sometimes when he couldn't solve a problem. However, he felt challenged and rewarded when he managed to solve it. Hence, he wrote, "mathematics is problem solving" as his image of mathematics in the questionnaire. He explained that, "yes, it seems most of the time, it's quite a lot of solving and using certain formulae and ideas" (text-unit 9). Consequently, his image of learning mathematics is like "riding a bike, it needs practice". To him, learning mathematics is like learning a skill, one needs a lot of drill and practice, it must be used in many different contexts and applied in various kinds of problems.

He experienced both good and bad moments in mathematics learning during different stages his schooling. As he illustrated,

> I went through stages where we were doing a topic and I just couldn't get a hang of it and I just got down and down. But most of the time, I just went to my teacher or I just struggled out of it. And all the time, eventually I just got it and understand about it. So it sorts of good and bad, it helps me to see that at the end of the day, you will get it. And it is quite rewarding after that. (text-unit 25)

In fact, his interest in mathematics increased when he started his A-level mathematics. He attributed his growing fascination in mathematics to his A-level mathematics teacher. As he said "you know, three years ago, I won't have had a lot of fascination about mathematics and I won't have considered taking it up at A-level..." (text-unit 29). But then "I think my A-level course is really a good course and the teaching of my teacher is really good and I got influenced by it. And I got good results and that kind of encouraged me a bit" (text-unit 31). Thus, Case 7 displays the important role of the mathematics teacher in fostering a student's interest in mathematics.

Besides his mathematics teacher, he also attributed his interest in mathematics to the encouragement of his parents, particularly his father. He believed that he has a "mathematics family" because his father is a mathematician and "he got the best master degree in mathematics in Birmingham" (text-unit 35). Hence, he was motivated to believe that he will do well in mathematics too.

However, he also believed that every one could be equally good in mathematics, provided they had the right teaching and the right attitude. In his opinion, the difference is only, "for some people, it might takes longer time to get interested than the others, but at the end of the day, I think everyone can be just as good" (text-unit 39). Accordingly, he believed that he inherited his parents' interest in mathematics, rather than their mathematical abilities.

In summary, case 7 displays a mathematics student who holds a very positive image of mathematics. Besides his own interest and positive attitudes towards mathematics (such as taking the difficulty as challenges), he has had a lot of positive encouragement and motivation from his parents and teachers too.

Case 8: R338

Profile: *A non-mathematics student *dislikes mathematics
** Age between 17-20 years old *female*

R338 says she dislikes mathematics because she found it "dull" and also "very complicated for quite a lot of it" (text-unit 3). She also believed that mathematics "got the image of [being] for clever people, it sorts of put people off from the beginning" (text-unit 3). She went on to say that, "I just can't understand the more higher stuff that you learn in college or university. The school stuff is fairly easier" (text-unit 5). She got a D for her GCSE and she felt that was "not so bad" (text-unit 5). Therefore, R338 seems to indicate the fact that she was not disgraced by her results in mathematics. Instead, she attributed her failure to the irrelevance of mathematics in her daily life and the bad image of mathematics. As a result, she portrayed her image of mathematics as "too complicated, obscure and unuseful for my life except arithmetic for shopping" while her image of learning mathematics as "dull like watching Paul Daniel" in the questionnaire.

Since her primary school years, she has found mathematics learning boring even though she did not find mathematics too difficult at that time. She believed that higher level mathematics (those at college and university) were too abstract and difficult to understand as she said "I think it is some, a lot of it, when you sort of look at it the higher level, it is sort of very complicated. I just can't understand the higher stuff that you learn in college or university. The school stuff is fairly easier, I think" (text-unit 5). Anyhow, she did not have much interest in mathematics. She preferred English and literature because these subjects are more interesting and also more "related to everyday life, that is sort of life I am much more likely to come into contact "(text-unit 21).

For a few moments of the conversation, she indicated that mathematics has a bad image and "the image of mathematics is just very boring" (text-unit 15). She believed that a lot of people found mathematics boring and disliked mathematics. According to her, "...when you get, or tell people that you are studying maths, then people will think, well, ….what a funny thing to study. I think the same thing because I am not interested in it myself" (text-unit 17). She believed that only those people who want to do engineering or become a mathematician would find higher level mathematics interesting and relevant.

To certain extent, she believed that her mathematics teachers could have influenced her view about mathematics. She described her mathematics teachers as, "I suppose it is about three out of five of them were a bit odd, not odd but a kind of eccentric, not even eccentric, some of them weren't very nice" (text-unit 41). But now, she has changed her view and believed that, "I suppose when you got older, you want to learn about something, that makes you more interested at it, isn't it?" (text-unit 41).

She did not attribute much influence to her parents although her dad was "fairly good at maths, but I don't think he influenced me very much" (text-unit 43). Instead she believed that her group of friends might have some influence on her because she "...think, we just kind of all thought the same thing about maths. Most school kids think that maths is dull but there is always an occasional one" (text-unit 46).

In sum, Case 8 displays a typical young non-mathematics student who dislikes mathematics because mathematics is boring and irrelevant. Without much encouragement and motivation from her mathematics teachers and parents, she did not feel too bad about her poor result in mathematics. In addition, she was very much influenced by the social stereotypes of mathematics, shared by her peers, that mathematics is only for the clever ones. Therefore, she is content that she passed her mathematics at GCSE level. It was only when she grew older that she sees the importance of mathematics and started to get more interested in mathematics. Thus, this case shows that a person's image of mathematics might be changed with age and maturation.

XI. Two special cases from the student teachers

Among the occupational groupings, the student teacher group seemed to display the most changed images of mathematics after they have followed their teaching courses in the university. In preparing themselves to teach mathematics to their future students, they are re-learning mathematics themselves. Hence, this experience of relearning has improved their understanding of mathematics, especially basic mathematics. Consequently, they have more positive image of mathematics than before. The following two cases chosen might help to illustrate further this process of change.

Case 9: R133

Profile: *A primary mathematics student teacher | *likes mathematics
** Age between 21-30 years old* | **female*

R133 expressed a strong liking of mathematics because she "can do it" and also she "can working things out" (text-unit 3). She found mathematics useful in everyday life. She also enjoyed the beauty of mathematics and the abstract aspect of mathematics such as mathematical theories and mathematical proofs. In her view, mathematics is "numbers, science and shape and also more than we think" while the learning of mathematics is like "understanding how things work in the world, nature and industry". She emphasised both the practical application and the philosophical aspect of mathematics in her explanation.

When she was at primary school, she never wanted to do mathematics because she never fully understood it. Suddenly at year 6, she found mathematics, "…not that difficult, I can do it and I can understand. And I suddenly shot up…" (text-unit 22). She attributed this change to her mathematics teachers whom she still could remember very well that, "…he explained it in the way that I understood" (text-unit 24). However, her mathematics experience was not always smooth. When she was at GCSE level, she met a mathematics teacher, whom she described as, "I just found his explanations really un-helpful. You know, he kind of showed me that he could do it but he didn't show me how I could learn to do it" (text-unit 30). Later at A-level, she found mathematics became more difficult but she was very happy with her mathematics teacher. This was because she "could go to him any time and he would stop what he was doing. He helped me to understand my maths" (text-unit 31). Thus, she stressed the importance of her mathematics teachers' explanations and encouragement, as an explanation for her success in mathematics.

Moreover, it was these positive experiences that she would like to carry over to her future mathematics teaching. She promised that, "he [her mathematics teacher] is the kind of person that I think about when I am teaching. What kind of teacher do I want to be? I want to be able to… when I see a pupil say. 'Miss, could I have some extra help?' I would stop, no matter what I was doing and say, 'yes, that was what I am here for and you don't worry I will help you'…" (text-unit 32). Obviously this case exemplified the significant influence of mathematics teacher on his students.

Besides her mathematics teacher, she also believed that her view of mathematics is also influenced by the society's view about mathematics. In her opinion, the societal image of mathematics is such that, "mathematics is difficult and no one likes it " (text-unit 47). This societal view of mathematics has actually motivated her to do mathematics because she "thought someone could be a bit more impressed if I say, yes, I done maths…I did feel that I achieved a lot more doing maths than if I have done the art" (text-unit 47).

She did not consider her parents had major influence on her views about mathematics but felt her peers did. This is because she found her friends very helpful, which was necessary, especially at her A-level mathematics. She "found [that] it really necessary to have a friend to work with me. It was helpful because you also knew that you wouldn't be the only one who didn't understand. Sometimes, you actually understood something they didn't understand and they understood something you didn't understand " (text-unit 57). Hence, her peers gave her both academic and emotional support in her learning of mathematics.

Case 10: R284

Profile: *A primary non-mathematics student teacher *dislikes mathematics
** Age between 21-30 years old* **female*

R284 disliked mathematics because she was put off by her mathematics teacher in school. She felt very confused and could not understand how and why she got that answer. At primary school, she was quite enjoying her mathematics lessons because "it was more fun and more flexible" (text-unit 7). When she got into secondary school, she found mathematics boring and irrelevant as she explained that, "I never understand them and as I need to do them, I always said, 'Oh! No' " (text-unit 9). As a result, she sees mathematics as "boring because you follow the same pattern all the time" while her image of learning mathematics is like "watching a foreign film without the subtitles". She expressed despair when she described her image of learning mathematics. She felt that, "because I don't, I could never, I never understood what they… You get told what to do but I never knew like why do I do this and how do I end up with this answer. Even if I ended with the right answer, why do I end up with this?" (text-unit 13).

During some parts of the interview, she blamed her mathematics teachers for her failures and negative attitude towards mathematics. For example, when she was asked if anybody else might have influenced her image of mathematics, she replied that "everyone else in my family likes maths. May be I just had a bad teacher that puts me off and I decided that I didn't like it " (text-unit 17). In another occasion, she agreed that some people have inherited mathematical ability, "probably to some extent, But I think everyone will probably managed it if they were taught properly in school" (text-unit 43). She also complained her mathematics teacher did not explain well and most often, she was just told to "do this do that, …and no one told you why you do it" (text-unit 25).

However, she has started to change her view about mathematics because she will soon have to teach mathematics to her students. It is also partly because her present teaching course has introduced her to some practical activities and she found these activities very interesting and practical. Thus she intends to apply them and promises to make her mathematics teaching more exciting and interesting to her students.

6.4 Summary of Chapter 6

To sum up, this chapter reported the full analysis of the interview data collected at the second stage of this study. These data were rich and illuminating. The results of the analysis of these data have partly served to confirm some earlier findings of stage one (e.g. the part on reported liking, and images of mathematics (learning mathematics)). At the same time, the analysis of these data have helped to illuminate further, in particular, the reasons for liking or disliking mathematics as well as the possible formative influences on these respondents' images of mathematics.

However, I have not discussed these results fully by linking them to my stage one data as well as related past literatures. Therefore, to get a more holistic picture of the sample's images of mathematics and the possible formative factors of influence of their images, I attempt to make a synthesis of the analysis results from both stages, and discuss these findings in relation to some related studies in the next chapter.

Chapter 7

Discussion of findings

The sample of the study was an opportunity sample, and only those who volunteered to participate were included. In spite of my efforts to stratify the sample by age and by occupational groupings, as well as to include as widely as possible all the social categories of the British public adults, certain sections of the public are inevitably under-represented while others are over-represented. Therefore, I acknowledge that the overall findings of this study are limited in generalisability and representativeness. However, the main aim of this study is not to present generalisations that can be taken as completely dependable. In fact, I am more interested in exploring the possible range of the public images of mathematics, and gaining a better understanding of the possible influential causes of these images. Hence, all the findings discussed in this chapter for these reasons must be interpreted with caution.

In addition, I acknowledge that using an open-ended question (as in the questionnaire) to ask for people's images of mathematics might have led to a variety of responses. There are possibilities that some respondents might just give an 'off the cuff' or unreflective answer to please the researcher. Others might have interpreted the term 'mathematics' in their own ways. In fact, there are at least three levels of mathematics that most public adults might have referred to, including (a) everyday mathematics, (b) school mathematics, and (c) academic mathematics (as discussed in Chapter 3, Section 3.4). Therefore, different levels of interpretation of the term might have resulted in different reported images of mathematics. However, it is beyond the scope of this study to clarify which is the level of mathematics that the respondents are referring to, except to be cautious when drawing any interpretations of the findings with regard to this issue.

However, having said this, because of the use of a large sample set and follow-up interview data, I would argue that it is possible for the data to illuminate and to help to gain a better understanding of the images of mathematics that were held by some people, even if only in a partial way. Coupled with the results of the other questions in the questionnaire, I would argue that the data has at least given us a glimpse of some of the images of mathematics of these respondents. Moreover, consistency between questionnaire and interview data suggests that these images were not just made up on the spot. Although this confirmation only available for data obtained from the small subsample that both completed a questionnaire and were interviewed, it does provide some basis for confidence on the stability of the responses. In addition, their links to respondents' learning experiences suggest deep-seated origins.

In Chapter 5, I analysed and reported the findings of the stage one data according to each questions asked in the questionnaire. Likewise, in Chapter 6, I analysed and reported findings of the stage two data collected through the semi-structured interviews. In this chapter, however, I attempt to synthesise the data collected from both stages, (both quantitative and qualitative) to build a coherent picture of the sample's images of mathematics. It appears that there are some common views emerging from these analyses. In addition, there are some significant differences in the images of mathematics between those who claimed to like and those who claimed to dislike mathematics. Thus, I attempt to discuss these images of mathematics, first according to the common views, then followed by a comparison between those who claimed to like mathematics and those who claimed to dislike mathematics. Lastly, I compare the images, beliefs and attitudes towards mathematics among the different gender, age and occupational groupings.

7.1 The range of images, beliefs of and attitudes to mathematics

The results show that a person's image of mathematics is often unique and personal, and multifaceted and diffuse. There does not appear to be a typical image of mathematics. Perhaps, there are some commonalities among certain sections of the population, with certain common factors of influence, but no single overall pattern or typical image of mathematics seems to appear. Instead of aiming for a common or typical image of mathematics, I believe that the diversity and variety of these images should be celebrated, as these illustrate the creative diversity of adults' attempts to encapsulate their perceptions of mathematics into an image, metaphor, description etc. As Rogers (1992) points out that it is

> This human desire to make stories about the world in our attempts to come to terms with the physical and metaphysical phenomenon we encounter daily has led to a vast fund of metaphors; of manipulating our images to enable us to come to terms in some way with the world we live in. (p.50).

Perhaps it is then not a surprise to obtain such a wide range of images of mathematics given in the forms of metaphors by the sample of this study.

7.1.1 Images of mathematics

Findings from both the quantitative and qualitative data suggest that the respondents' images of mathematics and learning mathematics appear similar, and overlap with each other. Thus, in the following sections, images of learning mathematics will be subsumed into the category of images of mathematics and discussed as such.

Many respondents did not seem to differentiate their images of mathematics from their images of learning mathematics. Even though the overall results of the whole sample (as shown in Chapter 5 Figure 5.6) suggest that images of mathematics were more often given in terms of the nature of mathematics, whereas images of learning mathematics were given as a process of learning. In fact, the majority of both images of mathematics (and learning mathematics) given by the respondents reflect their feelings and attitudes to mathematics. This is interesting because the results suggest that the word 'mathematics ' seem to have triggered off a more affective reaction towards mathematics than that of a cognitive entity. Indirectly, the findings suggest that these respondents' images of mathematics might have been derived from their experiences of learning mathematics. Likewise, their images of learning mathematics might reflect the mathematical contents that were presented or taught in school. Thus, in practice, most of the sample found it difficult to separate these two types of image. Kelly and Oldham (1992) observed similar results where both of their samples, the primary teachers and student teachers, could not differentiate their views about mathematics from their views about mathematics education. In brief, these findings suggest that there are very likely to have close links between mathematics and mathematics learning experience. Perhaps this is of no surprise as several researchers (Thompson, 1984; Frank, 1988; Ernest, 1996) have observed that school experience influences students' view of mathematics.

Five common views

Five views that were commonly shared by the UK sample emerged from a synthesis of both the quantitative and the qualitative data. In fact, these views were inter-linked and by no means as clear-cut as I propose here. However, for the purpose of this discussion, I will first describe and discuss each of them separately in the following sections. At the end of the sections, I shall attempt to give a coherent picture of the possible combination of these categories and themes in the sample's images of mathematics.

(i) ***Utilitarian view***: mathematics is primarily viewed in terms of its utilitarian value.

For example, Mathematics is viewed as:

> A human tool to calculate and predict. (R047)
>
> An essential tool for everyday life. (R128)

While this view of mathematics as a practical and useful tool might hold for those who reported liking, for others who dislike the subject, mathematics is perceived to be irrelevant and comprises

> a lot of things which I never used. (R492)

Nevertheless, for both groups, mathematics is viewed in terms of its utilitarian value. Mathematics is seen to be important because it has a practical value in everyday life. It has monetary value because it is needed at work. However, for a small group of respondents in this study, they did not see any practical value in mathematics, especially at the higher level of mathematics.

> When it involves day to day maths, such as calculating household budget or whatever, that's fine. But when it gets away from reality, from my reality, it doesn't have any direct relevance to me, I have no interest. I found those concepts very difficult to understand" (R218, text-unit 3)

Mathematics is regarded as important and essential to learn because mathematical knowledge is necessary and useful in both daily life and at work. Some reported images of mathematics strongly identified with particular uses such as "banking account" (R494) or "VAT receipts" (R459).

In spite of recognising the importance of mathematics, many respondents still found learning mathematics "not very exciting" (R007). One of the reasons given by a student was:

> It [mathematics] is a necessity, yes. Rather than something that could be enjoyable, something needs to be done and something can be enjoyed. But mathematics is something [that] need to be done rather than enjoyed" (R548, text-unit 31)

A utilitarian view of mathematics is held commonly by the majority of the sample, whether they reported liking or disliking. Perhaps this is not a surprise in view that this utilitarian aspect of mathematics has been the focus of our contemporary education (Cockcroft Report, 1982). Moreover, previous studies on students' (APU survey, 1988 & 1991) and teachers' (Kelly & Oldham, 1992) attitudes towards mathematics have also shown that the majority of these sample viewed mathematics as useful and important.

(ii) ***Symbolic view***: mathematics is perceived as a collection of numbers and symbols, or rules and procedures to be followed and memorised.

Some examples are where mathematics is viewed as comprising or being represented by:

> numbers and equations (R005)
>
> figures and sums (R340)
>
> multiply, minus, add, divide (R453)

For many of these participants, mathematics is seen as sets of rules and procedures to be followed and memorised. For some respondents, this is a pleasure because mathematics is

> formulae, involved and exciting. (R038)

And some of them just

> like playing around with numbers, equations, finding solution to problems
>
> (R119, text-unit 3, likes maths).

But to others, mathematics is

> rules, formulae learnt before understanding. (R109)

This is well described by a middle-aged respondent who reported disliking mathematics.

> Sometimes if you can't remember the formula then you don't know how to get the answer,…(text-unit 5) and
>
> …you got to stare on the wall. You are mentally blackout - it is all gone! (text-unit 13)

As a result, she said,

> I haven't had any interest at all. I find it [mathematics] boring, doing numbers and things like that. (text-unit 37)
>
> (R267, housewife, 31-50, dislikes maths).

Many respondents perceived mathematics as a collection of numbers and symbols, rules and procedures that are needed to be followed and memorised, that is, the symbolic view of mathematics. Many of them indicated that they did not understand mathematics and did not see the purpose of this repetitive process. This perceived irrelevance has resulted in boredom and sometimes confusion for some of them.

Implicitly, this view is also related to dualistic view such that there is always a right or wrong answer for a mathematical problem. Consequently, there seems to have a fixed set of rules and procedures that need to be followed or memorised so as to get the right answer. As a result, some have experienced mathematics learning as "boring because you follow the same pattern all the time" (R284). Others found learning mathematics as "torture, endless letters and figures with usually endless little explanation" (R156). Perhaps it is plausible to find those who found mathematics boring are also those who hold this symbolic view of mathematics. The data thus far has indicated that those who reported a disliking of mathematics and the young non-mathematics students most commonly hold this view and they are also the majority who expressed that mathematics is boring.

These findings seem partly support findings of several past studies on students' beliefs about the nature of mathematics (Frank, 1988; Cesar, 1995). Although the samples for these studies were either middle school students (e.g., Frank, 1988) or 7th grade students (e.g., Cesar, 1995), they too viewed mathematics as computation and mainly involved memorising rules and procedures. Thus, the findings of this study suggest that a symbolic view of mathematics might have taken root since an early age and it has persisted till later ages of life.

(iii) ***Problem solving view***: mathematics is related to a set of problems to be solved.

The main characteristic of this view is that mathematics is taken as a set of problems to be solved. The enjoyment of learning mathematics then lies in the exploration of these problems and the derivation of solutions. Many respondents reported a sense of satisfaction and achievement when they found the solution to a mathematical problem.

> There is always enormous pleasure in manipulating numbers a kind of problem solving activity in its own right. So, if I have a mathematical problem that I basically, provided that I understand the rules, then I have quite a lot of pleasure in manipulating that out of whatever it might be. Although I am largely a verbal person, I am also have great fun in solving mathematical problems
>
> (R061, text-unit 5, university lecturer (psychology), age group 51-60, male, likes maths)

In the process of solving mathematical problems, many believe that mathematics stimulates logical thinking and functions as an analytical tool. This is because mathematics is "logical stimulation" (R100) as well as "logical - organises things in order" (R122). Subsequently, mathematics is viewed as a means to model the world. A few respondents expressed that maths is

> a way to model the physical world (R301) and
>
> problem solving - explaining physical processes. (R113).

Associated with these images is the view that mathematics learning is "learning to think correctly and logically" (R384) and it is possibly hierarchical in the sense that, one needs to "take small steps to understand difficult problems" (R122). Moreover, mathematics learning is all about "making order out of chaos" (R118).

This problem solving view was more often held by those who reported liking than those who reported disliking mathematics. For the former, this was also given as one of the main reasons for liking mathematics. Perhaps they enjoyed the challenge in searching for solutions to mathematical problems, and felt a sense of satisfaction when they found a solution. In contrast, for those reporting disliking mathematics, learning mathematics is like "solving a complicated puzzle: there is an answer but it takes long time to find it" (R361)

Many of them find mathematics "difficult" (R434) and learning mathematics is more like "passing hurdles" (R470) than doing something enjoyable.

(iv) ***Enigmatic view***: mathematics is seen as mysterious but yet something to be explored and whose beauty is to be appreciated.

For these respondents, mathematics is seen as mysterious, foreign and incomprehensible but yet, it is also "like a sunset - unique and beautiful" (R168).

There are on one hand, those who like mathematics because, as they reported:

> …I like the elegance of mathematics. The proofs and theories are very elegant. There is …like recognising the patterns of mathematics, I found it very interesting.
>
> (R193, text-unit 3, IT trainer, male, 21-30, like maths).

Due to the elegance and aesthetic appeal of mathematics, and for others, the mysterious nature of mathematics, learning mathematics becomes "an exploration into another world" (R113) or " a voyage of discoveries" (R116) that is "fun and challenging" (R140) for those who reported a liking of mathematics.

On the other hand, the complexity and abstract nature of mathematics also drives away some people's interest in mathematics because they found mathematics incomprehensible and confusing. They found themselves like "groping through fog" (R412) or "wandering in a desert - with the odd oasis of understanding" (R363).

The view of mathematics as an enigma was expressed by a minority of the sample, particularly those who reported liking mathematics and those who have direct involvement in mathematics such as mathematics students and mathematics teachers. Perhaps this might be one of the reasons that have attracted these people to undertake mathematics-related studies and careers. Nevertheless the likely correlation between this enigmatic view and reported liking of mathematics suggests that the promotion of this view may lead to a more positive image of mathematics. However, this is merely speculation without any substantial research evidence.

(v) ***Absolutist or dualistic view***: mathematics is perceived as a set of absolute truths, or as a subject of which always has right or wrong answers.

For example, this view is characterised by

> … in maths, you got the right answer or the wrong answer. There isn't anything in between.

(R115, text-unit 15, student adviser, age group 41-50, female, dislikes maths)

> Maths is fun and [has] definite answer to work to.

(R313, insurance sale assistant, age group 31-50, female, likes maths)

According to this view, mathematics appears to have a power of certainty, such that,

> I just like the fact that you could get a solution and that nobody could say that you have done wrong.

(R113, text-unit 7, science teacher, age group 51-60, female, likes maths)

Due to this certainty, many respondents find learning mathematics rewarding and a source of achievement.

> Obviously if I can get the right answer, I feel achieving and rewarding.

(R409, text-unit 11, retired soldier, age group over 60, male, likes maths)

However, this view of a definite right or wrong answer has hindered some respondents from liking mathematics. This is because they found mathematics lack creativity and it is not discussible. One young PhD student (sport science) gave his reason of disliking mathematics as,

> Mathematics is sort of not very questionable, for example, probability is probability, it is difficult to question probability and things like that. So because in that aspect, then you know the learning reflect the type of subject it is. Therefore it is not very discussed like that. You learn trigonometry and you don't discuss trigonometry.

(R548, text-unit 37)

Thus, in terms of this absolutist view, mathematics is perceived to be a set of absolute and unquestionable truths. Concurring with the analysis proposed by Ernest (1991), mathematical knowledge is viewed as a precise and "exact science" (R190), which is "clean and straight forward" (R395). Consequently, in more simplistic views, mathematical answers are believed to be either right or wrong.

The absolutist or dualistic view seems to be one of the typical and widespread images of mathematics because this finding is supported by the findings of Kelly and Oldham's (1992) study of primary mathematics teachers, Knudtzon's (1996, 1997) study of students teachers, Buerk's (1982) study of women and Sewell's (1981) study of public adults' everyday use of mathematics.

In general, these five commonly shared views and their frequencies of occurrence can be summarised and it is as displayed in Table 7.1. The frequency of occurrence refers to the number of respondents whose responses in the open-ended question or the interview transcripts indicate the corresponding views. For example, there were 62 responses to image of mathematics which indicate a utilitarian view, 15 responses to image of learning mathematics that indicate similar view and 31 respondents' interview transcripts that indicate likewise. Thus, there is a total of 108 respondents that indicate a utilitarian view of mathematics, either in their responses to image of mathematics or learning mathematics, or during the interviews. However, not all the responses can be classified into these five views. In other words, the frequency can only be used to show how common were these views being espoused by the respondents of this study.

Table 7. 1 thus shows that the utilitarian view and the symbolic view were the two most commonly shared views while the absolutist view was the least common among these views that seem to recur in this study. The latter result was a surprise to me because I would have expected it to be the most common one. As reviewed earlier, an absolutist or dualistic view of mathematics was found commonly exhibited by adult learners (Burton, 1987), highly educated women (Buerk, 1982; Sewell, 1981), and some student teachers (Wilson, 1992; Knudtzon, 1996, 1997). Nevertheless, as explained in the following section, many respondents had indicated in their interviews that they tended to hold more than one single view. Moreover, many of the alternative views held were independent of the absolutist-fallibilist dichotomy, so different weightings overall attributed to these views are perhaps not surprising. Furthermore, another explanation could be that the term 'mathematics' might have been interpreted or referred to 'school mathematics' by many of the respondents in this study, and thus might have resulted in a more symbolic view of mathematics. This remains speculation without further confirmation from the respondents.

Table 7.1: Characteristics and frequency of occurrence of each common view

4. Enigmatic view	

Composite view

The results show that in general most people were inclined to hold a composite image made up of elements from several of these five common shared views rather than subscribing to a single view.

For example, there were those who indicated both absolutist view and problem-solving view. Maths is

> logical system applied in various areas of life - the only thing that have complete surety (R337).

There were also a few who exhibited more than two views, though at different degrees of intensity. For example, an university lecturer who reported a liking of mathematics, viewed mathematics as having an *utilitarian* value such that,

> mathematics is a game or *a tool* for me and no more, not a way of life. (text-unit 13)

but

> the second thing is there is always enormous pleasure in manipulating numbers as a kind of *problem solving* activity in its own right. (text-unit 5).

Although he held certain degree of *absolutist* view, that

> I think mathematics is something which is *very definite*, it is a , you know, once you got the rules structured, then that rule structure is applied, no matter how you are using mathematics. (text-unit 11)

He was aware that,

> I like to point out again, what I am very aware of is in the higher order of mathematics, the *certainty* of it begin to *become less and less*. (text-unit 17)

In spite of this, he viewed mathematics as *enigmatic* because

> …it is the sense of there is a mathematical solution, that is there and which I can reach and it is not affected by the other considerations. It is sometimes very refreshing. (text-unit 21).

Therefore, the data shows that there emerged five common views of mathematics but most people seem to hold a composite view rather than a single view of mathematics. Interestingly, these results are consistent with what have concluded by Mura (1992) that, "not only do different persons have different perceptions, but individuals may hold composite view" (p.16).

7.1.2 Image as metaphor

Lakoff and Johnson (1980) point out that "metaphor is pervasive in our everyday life, not just in language but in thought and action" (p.3). Perhaps it is then not unusual for people to express their images in the form of metaphors. In this study, 27% of the respondents expressed their images of mathematics in the forms of metaphors, while 66% of them gave their images of learning mathematics in metaphoric terms. It is interesting to consider the variety and diversity of these metaphors, besides the commonalities that they shared. Some common metaphors used by many respondents are described and discussed as follows:

a) Mathematics as a journey

This was the most common metaphor given by the sample. Some examples are:

Mathematics is a

> challenging journey - rewarded by arrival at your destination (R255).

Learning mathematics is like

> an easy stroll on a windy day (R034)
>
> running uphill - difficult but you get there (R376)

Implicitly, the journey metaphor highlighted the close relationship between images of mathematics and images of learning mathematics. For many, mathematics as a challenging journey elicits the experience or process of learning mathematics. For some people, the experience of learning mathematics might be like a struggle in a journey such as, "walking through mud" (R155) or "an uphill struggle" (R417).

These metaphors indirectly indicate the difficulty and frustration that were experienced by these respondents, especially those reporting a dislike in learning mathematics in school. Some of them felt that learning mathematics is like "being stuck in a bus queue" (R268) or "climbing a topless mountain" (R104).

They felt helpless and anxious about their inability to understand mathematics. A salesman expressed his image of learning mathematics as "driving a Boeing 707 (I don't fly)" (R462). Later in the interview, he explained that,

> It is an expression that I use when someone says it is easy, all you got to do is this. It is easy if you can fly and you know how to drive a Boeing 707. But if you sit in front of a 707, where do you start? You know that you want to take off. You know that you want to start the engine. You want to go forward but you don't know how. So, you have the interest. Sometimes the interest is there but the lack of comprehension of how the whole thing work, it means you don't progress any further. "

(text-unit 19, male, over 50, dislikes maths)

Thus it is sad to notice that some people might be full of interest before starting the journey of learning mathematics, but their interest was killed off by their lack of understanding.

In contrast, particularly those who reported a liking of mathematics viewed these journeys as explorations or discoveries. For them, learning mathematics is like

> exploring - there is always something new to know (R331) or

> being an explorer-finding new paths and worlds (R364)

For these people, mathematics is a journey to discover new things, new knowledge and new insights. A middle-aged mathematics teacher described his images of learning mathematics as "the best sort of travelling in a new land" (R293) and he explained that,

> Well, when you are studying a new area and you are having to grasp it sometimes, you know, because you haven't done that sort of mathematics before and you begin to realise why some statements, some theorems in mathematics are true or you begin to see the use of that theorem can have, you know, the statement is making connection without the thing, and that I find interesting.

(R293, text-unit 9, male, mathematics teacher, 41-50, likes maths)

These results suggest that it was the joy of discovering new understanding in mathematics that attracted them to get interested in mathematics. Even though many of them also found learning mathematics a difficult journey like,

> a journey through a dark tunnel with a light at the end (R139) or
>
> walking through sand - hard work but put in effort, you'll get there (R136)

Therefore, there is this sense of achievement and satisfaction that encourage these people to work hard and to strive for solution. Implicitly these metaphors indicate that there is a definite solution for each mathematics problem. Learning mathematics is "a journey through a dark tunnel with a light at the end" (R139) and there is a destination for you "to get there" (R133, text-unit 13).

There was also a young mathematics student who used journey metaphor to illustrate her change of view from absolutist to fallibilist (Ernest, 1991):

> I mean we always brought up with that of the right and wrong answer and suddenly we were told that was not the most important part of maths, the most important part is *how to get there*, what kind of strategy to use. You know, that is the important part, how to get it done. ...Therefore, mathematics does not have a definite solution. It is really *your journey to get there*.

(R133, text-unit 13, italic added)

According to her view, she was brought up with an absolutist view, but now she was exposed to an alternative view that there are many strategies and possible answers to a mathematical problem. To her, learning mathematics should be focused on 'process' rather than 'product'. This fallibilist view, however, was only shared by very few respondents.

It is interesting to read that some undergraduate students and tutors in Allen and Shiu's (1997) study also gave the metaphor of mathematics as a journey. They categorised these responses under one of their four categories: "struggle leading to success". Two very similar responses from the tutors are: learning mathematics is like

> climbing a hill: - hard work where you follow the path you're on - and then the joy and satisfaction of being at the top (T3)
>
> climbing a hill. The higher you get the clearer the view of surrounding countryside - as you can see more the links and layout and connections become more obvious. (T18). (p.10)

In short, 'mathematics as a journey' metaphor indicates that mathematics learning is a difficult process that needs a lot of effort and time. However, there are two possible extreme outcomes: either you reach the destination (obtain the solution) and feel happy and satisfied, or the opposite, fail to solve the problem and feel disappointed and frustrated.

b) Mathematics as food metaphor

The mathematics as food metaphor was the second common metaphor used by many respondents in the study. However, despite the positive associations of food, these metaphors used were more often associated with negative feelings of varying degrees rather than with positive ones. These metaphors indicated

(i) difficulty, such as mathematics is "toffee (hard and chewy)" (R235) or

(ii) boredom and irrelevancy such as mathematics is "a boring recipe - not relevant to real world" (R499) or

(iii) confusion, such as mathematics is "like alcohol, the more you consume the more confused you get" (R141).

On the other hand, there were four respondents who used the food metaphor to indicate positive feelings such as enjoyment. Mathematics is like, "eating a buffet - lots of tastes" (R255) or "eating chocolate spread - yum yum" (R305).

In between these two extreme groups, there are a number of them who used food metaphors to imply mathematics as a necessary evil. Food is a necessity for life but not all types of food are tasty. Similarly, mathematics is viewed as essential in life, but learning mathematics might not be always as enjoyable as everyone hope for. Therefore, learning mathematics is like,

> a box of chocolates, you never know what you'll get next (R168).

These experiences of learning could also be increasingly difficult for some people, learning mathematics is like,

> like a peach - soft on edges but at the core hard like a stone (R136)

or getting easier for others, such that learning mathematics is like

> a boiled egg - hard when you look at it but soft when you do/eat it (R127).

In brief, the 'mathematics as food' metaphor is closely related to a utilitarian view of mathematics. Accordingly, mathematics is perhaps a kind of important and essential food needed for survival or use in life. However, just like not all foods are delicious and suited to the taste of everyone, learning mathematics is viewed as not always easy and enjoyable. More often, learning mathematics is experienced as *difficult, painful, boring and confusing*.

c) Mathematics as a skill

Closely linked to a utilitarian view of mathematics, some images of mathematics portray mathematics as an important and necessary skill for daily life and work. Mathematics is

> an essential basic skill for society (R092).

Similarly, learning mathematics is like:

> learning to walk, we've all got to (R009).

Once again, the skill metaphors reflect the view that mathematics is a skill that is not always easy to learn, just like

> learning a musical instrument, some are easier and others are extremely hard (R542).

Nevertheless, at least nine respondents were attracted to learning mathematics because to them, learning mathematics is acquiring a skill, like "riding a bike - once learnt never forgotten" (R123).

There were some respondents who viewed mathematics as a set of skills that is hierarchical, like " brick laying - each brick is the foundation for the next block" (R081).

Others believed that mathematics learning is a skill that needs

(a) memorisation such as "learning law: rules and cases to remember in total" (R485) or

(b) needing a lot of practice: "learning to ride a bike - takes plenty of practice" (R520).

Likewise, the skill metaphor for mathematics suggests that learning it could be a skill that develops more easily for some people, like playing the stock exchange - once you get the hang of it, it's ok (R469),

or gets more difficult for others, just like

riding a bike, simple enough until you come to a mountain (R066).

In summary, 'mathematics as a skill' metaphor suggests that mathematics is viewed in terms of its utilitarian value, while learning mathematics viewed as a skill is seem to be hierarchical, needing memorisation and lots of practice; difficult to be mastered by some but easy for others.

d) Mathematics as a daily life experience

Besides the above three most common metaphors in our sample, mathematics is also commonly given in terms of an experience, in particular, a negative daily life experience. Mathematics as a metaphor of daily life experience has been used to portray a wide variety of feelings, from enjoyable:

like playing with my children never tiresome (R526)

to painful:

a pain in the arm (R181) or

a big headache (R523).

More often these metaphors indicate learning mathematics as a negative rather than positive experience. For example, learning mathematics is

- as boring as "going to sleep" (R003) or "watching paint dry" (R006)
- as painful as "having a tooth pulled out" (R078)
- as frustrating as " being stuck in a bus queue" (R268) or
- as (presumably) unpleasant as "having to walk to work in the rain" (R110).

Nevertheless there were a few respondents who indicated positive experience of learning mathematics like, "watching TV never want to switch off" (R526) or having "a cold shower - refreshing" (R061).

A few respondents experienced mathematics learning as something that is necessary even though they had feelings of 'unwillingness' or 'forced to'. For example, learning mathematics is like

> being dragged unwillingly along (R278) or

> like going to see the doctor - horrible but sometimes necessary (R208).

A young librarian gave an interesting metaphor for mathematics as "sitting in a class on a hot day wanting to be somewhere else", and she explained in the interview that,

> R207: I think it is something personally for somebody in the classroom you find for every subject, especially if it is the subject that you don't like. That is the last place that you want to be in a maths room when the sun is shining outside. [laughter all along]
>
> I: Do you mean you feel that you are forced to do it?
>
> R207: Ya. Yes, maths is something that you have to do to do anything later on. You have to get the maths qualification. And if you not good at it or you don't like it, then it is very much, you know, struggle to do it."
>
> (R207, text-unit 11-13, female, age 21-30, dislikes maths)

In summary, mathematics is viewed as part of life experience and learning mathematics is viewed as more often related to negative experience for most people, at least in this study.

e) Mathematics as a game or puzzle

Closely related to problem solving, some respondents viewed mathematics in terms of games and puzzles. It is like "a brain teaser - a puzzle to be solved" (R388) and learning mathematics becomes

> finding your way through the maze (R174); or

> playing chess - absorbing and challenging (R220).

Viewing mathematics as a game or a puzzle to be solved reflects the fact that mathematics learning is fun and challenging for some people. Mathematics is

> fun when everything works out but remains a challenge (R470)

or learning mathematics is like playing

> a jigsaw puzzle - slow but relaxing- it makes your mind work (R389)

Interestingly, out of the 10 respondents who expressed their images of mathematics as games or puzzles, nine of them are female and all of them reported liking mathematics. These results suggest that some female respondents like mathematics because they view mathematics as solving puzzles and playing games. How widespread this is, is not known.

7.1.3 Beliefs or myths about mathematics

Mathematics is difficult

This is the most common theme or belief, which emerged from both the quantitative and qualitative data. 70 respondents indicated that this notion of difficulty was a part of their image of mathematics. These respondents viewed mathematics as a subject that is difficult to understand, that needs a lot of hard work and extra effort. Consequently, some believe that one needs to have a special mathematical ability to be good at mathematics.

> I think mathematics is very brain power [driven], you need a good brain.
>
> (R165, text-unit 15)

But as she perceived herself that,

> I didn't have the brain power to actually use it and do it properly, so I just got bored with it…
>
> (R165, text-unit 17)

The result suggests that this notion of difficulty is widely associated with mathematics, whether or not the respondents reported a liking or disliking of mathematics. The only difference between them is the former take it as a challenge and strive hard to solve it. When they obtain success, they may feel rewarded and satisfied. In contrast, for those reported a disliking of mathematics, they may demonstrate the experience of frustration and loss of self-confidence in mathematics. These respondents may also work hard but frequently they fail. They may, therefore, feel frustrated after much hard work. They may tend to blame themselves for lack of mathematical ability or put the blame on others' fault (particularly, their mathematics teachers). The following conversation illustrates an example:

> Interviewer: Do you mean you find maths difficult to understand?
>
> R025: Yes, I think the teacher that I have didn't make much effort to make me understand it. For a lot of time I kind of frustrated. When I had a good teacher then it all paid together, that was when I really enjoyed it.
>
> Interviewer: Do you mean you did not have a very good maths teacher during your school years?
>
> R025: Well, I think during my high school. Primary school I had quite a good maths teacher. High school, I didn't have a very good teacher and that was the level that I found it difficult but after that level, I have given up.
>
> (R025, text-unit 4-9, female, ecologist, age group 21-30, dislikes maths)

It may be that some experience repeated failure and this further strengthen their belief that mathematics is difficult and beyond their means. This may lead to further dislike or strong negative feeling towards mathematics, such as "I hate it" (R042, text-unit 3) or "it leaves me feeling cold" (R218, text-unit 29).

This result seems to concur with Cesar's (1995) on the 7^{th} level pupils from Lisbon and the 11-year-old and 15-year-old pupils in the APU surveys (1988, 1991). These findings suggest that the belief that 'mathematics is difficult' seems to have taken root from a very young age and it has persisted even at latest ages of life.

Mathematics is only for the clever ones

In this study, 95% of the respondents agreed that some people are better in mathematics than the others. Half of them attributed the difference to having inherited mathematical ability. This result supports findings from cross-cultural studies (for example, Ryckman & Mizokawa, 1988; Chen and Stevenson, 1995) and review on cross-cultural studies (see Stigler and Baraness, 1988) that it is common for the Western or Anglophone countries to explain success in terms of mathematical ability, while the Eastern countries typically emphasise effort as the source of success in mathematics. However, more recently, the above oft-quoted Anglo-Saxon belief in ability seem to be challenged by findings of some studies (e.g Gipps & Tunstall, 1998; Elliot, Hufton, Hildreth & Illushin, 1999). These findings show that effort rather than ability has been quoted as major reason for success in mathematics (Gipps & Tunstall, 1998) and in school work (Elliot et al., 1999) by the English young children. Albeit inconclusive, findings of this study suggest that the old belief of ability more than effort might be still more prominent among the adult members of the UK public, at least in this study.

It follows that those who exhibit low self-confidence about their own mathematical abilities may tend to believe that they themselves lack of this 'mathematical brain' or 'mathematics is only for the clever ones'. As a result, they are far behind the others in mathematics performance. This is illustrated by an interview with a salesman:

> R462: I think it is an intellect thing. There is little bit missing in my brain that it doesn't pick up on that. And it switches it off.
>
> Interviewer: Do you mean you believed that in order for someone to be good at maths, he or she must have inherited mathematical ability?
>
> R462: Hmm [pause a while]. From my experience, it was never set a light to me. I never have that, it just doesn't come alive for me.

(text-unit 25-27, male, over 50, dislikes maths)

A primary science student held similar belief that,

> I think mathematics has been put across to me as something incredibly difficult and only clever people can do it and you are [she is] not one of the people…

(text-unit 27, female, dislikes mathematics, 21-30)

Some similar responses given in the open-ended questionnaire include:

mathematics is

> interesting but [my understanding] has not progressed much beyond my ability to appreciate it (R464)

or learning mathematics is

> trying to learn but it can't work - very hard, I can't do it (R094).

Further analysis of the interview data identified two possible types of responses on this issue of having innate mathematical ability. Eight interviewees strongly believed that mathematics is "a subject that required certain type of mind" (R415) and it is "either you have it or you haven't" (R043, text-unit 35). In contrast, six respondents believed that it is possible for everyone to be equally good at mathematics provided one is taught properly and received sufficient encouragement and motivation from both their parents and teachers. For example:

> I think everyone, everyone can, you know, it is a lot to do with teaching and everyone can be good at it. I think a lot of time, it is whether they want to be. Some people feel that it is not a lot of real life usage and they are not interested in it. But I think with the right teaching and the right attitude, then anyone can do it and anyone can be good at it. It might take, you know, for some people, it might take long times to get interest than the others but at the end of the day, I think everyone can be just as good. (R370, text unit 39)
>
> But I think also, I mean, it is a bit like saying musical talent, it just seem to be the case that some people have talents in certain directions more than the others and it doesn't mean that people with little talent can't become good... But I think this is a nature-nurture thing, you know, there is some remain for others and also culture thing can or may have a big influence.
>
> … for example, if you have a child in a family that has a high respect of education or a culture that has [high] respect [for maths], that's very helpful. Yes, for the respect, for the effort and for the work. No great achievement without work.
>
> (R399, text-unit 35-39)

In summary, this myth seems to be held by many respondents in this study, albeit in different degree of certainty.

Mathematics is a male-domain

The findings of this study both support and challenge the belief that there is a gender difference in mathematical ability. 78.5% of the sample believed that both genders can be equally good at mathematics. Only a minority of 15% believed that men are better in mathematics than women. Further analysis of the data show that the males, the professionals, the young people group (aged between 17-20 years old) and the non-mathematics students were the dominant subgroups who believed most noticeably that mathematics is a male-domain. While the overall result seems to challenge the widespread societal view that mathematics is a male-domain, the detailed analysis supports previous studies (see Burton, 1989; Vermeer, Boekaerts & Seegers, 1997; Vanayan et at., 1997) that more boys than girls believed that they are good at mathematics.

Moreover, the result indicates that about 16 % more female respondents believed that they can be equally good at mathematics but only 5% of them believed that they can be better than men in mathematical ability. These results, albeit subtly, confirm the results of past studies on adults (see Sidwell, 1981; Colwell, 1998) that women tend to show less self-confidence in their own mathematical abilities than their counterparts.

Perhaps, it is then not a surprise to notice phrases such as the following surfaced in the interview data:

> R220: Yes, I think that's very true. Girl is good at English and French, boy is good at maths and science. Certainly in my days, what I mean, we were talking about 35 years ago, hmm, that was certainly present, I would hope that it wasn't now.
>
> I: So, could I say that you were influenced by this view of society that you feel that as a girl, it is alright if you are not so good at maths?
>
> R220: Yes, I am sure that's the reason.
>
> (text-unit 51-53, likes mathematics, middle-aged, female professionals)

In brief, it is a promising indication that only a minority of the respondents held the myth that 'mathematics is a male dominated subject', as far as the results of this study show.

7.1.4 Image and past learning experience

As indicated in Chapter 3, an image is a personal construct. It is presumably constructed from what we have perceived and experienced, including what we believe and value. It follows that one's image of mathematics can be expected to be closely linked to one's past experience, in particular past mathematics learning experiences in school.

In Section 7.1.1, I discussed the five common themes in images of mathematics that emerged from the data. Based on this broad classification, I would like to consider whether there is any possible link between the presence of these commonly shared views and the respondents' past mathematics learning experiences.

However, further analysis of the interview data suggests that there was no clear-cut correlation between these five types of view and past learning experiences. Perhaps this is not a surprise since most respondents in this study seem to hold more than one of the five commonly shared views of mathematics.

Instead, the analysis shows that there were significant differences displayed in many aspects between those who reported liking mathematics and those who reported disliking mathematics. Therefore, I now turn to make an overall comparison between these two distinct groups, and discuss these differences in the following sections.

7.1.5 An overall comparison between those reported liking of mathematics and those reported disliking of mathematics

First of all, I found the result on reported liking very useful because they allow me to divide the sample into two distinct groups -- those reporting liking mathematics and those reporting disliking mathematics. Both groups appear to exhibit significant differences in many of the constructs investigated. Secondly, the high correlation between reported liking and category of feelings (see Chapter 5: Section II.5) also prompted me to choose these constructs as a basis of comparison.

In short, based on these two constructs, 'reported liking' and 'category of overall feelings', I can divide my sample into nine subgroups. However, five subgroups that indicated 'unsure' in reported liking and 'neutral' in category of overall feelings were ignored because the number of respondents in these groups were negligible. Similarly, due to the relatively small proportion of sample (n=5) who were grouped under reported disliking and positive category of feelings, this group is also excluded from the overall comparison analysis. As a result, I have three groups left for comparison: (i) those reported liking mathematics and expressed positive feelings, (ii) those reported liking mathematics but expressed negative feelings and (iii) those reported disliking and expressed negative feelings.

Subsequently, I explore the dominant features of these three groups, in terms of their categories of images of mathematics and learning mathematics, beliefs about mathematical ability and gender differences in mathematical ability, views about the importance of school mathematics and beliefs about the nature of mathematics. The results are summarised and displayed in Table 7.2. Here I used the same categorisation of image of mathematics (and learning mathematics) as described in Chapter 5 Section III. It is to be noted that the figures given in parentheses indicate the number of responses that fell into these main categories or subcategories. As discussed in Chapter 5, these categories or subcategories were not mutually exclusive because each response to image of mathematics (learning mathematics) can be coded into more than one category or subcategory. However, the percentages shown in parentheses were calculated based on the sample size of each subgroup discussed.

Table 7.2 shows that, all the three groups have their images of mathematics fell into the same two dominant categories, namely 'attitudes' and 'the nature of mathematics', but these images were strikingly different in the dominant subcategories. For those who reporting liking mathematics, more than 10% of them (out of 135) viewed mathematics as *enjoyable, interesting and challenging*. In contrast, for those who reporting disliking mathematics, 10% of them (out of 105) viewed mathematics as *difficult, boring, frightening albeit important and necessary***.** Moreover, the former appreciated *the beauty of mathematics* while the latter equated mathematics to *equations.*

Table 7.2: An overall comparison between those reported liking mathematics and those reported disliking mathematics

		Both the same (84.4%)
	A mathematical problem can be solved in different ways (90.4%)	

In terms of image of learning mathematics, although both those who reported a liking of mathematics and those who reported a disliking of mathematics have their images of learning mathematics fell into the same dominant categories of 'attitudes' and 'process of learning'. It is interesting to observe that for those who reported a liking of mathematics they tend to view mathematics as a process of learning, whereas for those who reported a disliking of mathematics described their images of learning mathematics in attitudinal terms. Similarly, for 10% of the first group, learning mathematics is viewed as a *problem solving activity, an exploration and mysterious in nature*. In contrast, 10% of the second group experienced mathematics as *a struggle, a difficult, painful and frightening process of learning.*

These results thus suggest that there are possibly close link between reported liking of mathematics and the images of mathematics and learning mathematics. Perhaps it is not surprising to observe that those respondents who claimed to like mathematics tend to exhibit a positive image of mathematics, whereas those respondents who claimed to dislike mathematics exhibit a negative image of mathematics. Likewise, those respondents who claimed to like mathematics but expressed negative feeling (the middle group) seem to exhibit a rather 'neutral' image of mathematics, such as mathematics is difficult but challenging, and learning mathematics is like doing puzzles and games.

However, all the three groups did not seem to display much difference in terms of their beliefs about gender differences in mathematical ability, reasons for the importance of school mathematics and beliefs about the nature of mathematics. Nevertheless, the significant difference observed in their images of mathematics and learning mathematics prompted me to make a comparison of their reasons for liking or disliking mathematics as well as their experience of learning mathematics in school. This is where I shall turn to discuss in the next section.

7.2 Reasons for liking and disliking mathematics

Analysis of the qualitative data (see Chapter 6 section I and II) shows that there were significant differences between reasons for liking and disliking mathematics. These differences appear closely related to one's beliefs about own ability, views about mathematics and causal attributions for success and failure. As I have described the analysis in detail in chapter 6, here I summarised these results in Table 7.3. Partly based on Weiner's (1983) causal attribution theory, I also proposed the possible causal attribution to each reason given in Table 7.3

		Possible causal attribution
	■	
	■	
	■	Absolutist or dualistic view of mathematics
	■	Problem solving view
	■	
	■	
	■	
	•	
	•	
	•	
	•	
		Others

An interesting observation is that the list of reasons for disliking mathematics seems to partly fit with the model of attribution theory for motivation and emotion (as suggested by Weiner, 1983 & 1986). However, for those who reported liking of mathematics, their reasons for liking mathematics seem to be affected more by their views about mathematics, besides partly follow the model of attribution theory (e.g., beliefs about own ability).

The reasons given for liking mathematics seem to show that those who reporting liking mathematics have intrinsic motivation for learning mathematics. These respondents believed that they were good at mathematics, thus they have the possibility of succeeding (*expectancy*). In addition, they appreciate the *value* of mathematics because they can use it in their daily life or careers. Thus, it follows from the expectancy x value theory of motivation (see Feather, 1982; & Grouws and Lembke, 1996) that as these two conditions are fulfilled, these respondents are intrinsically motivated to learn.

Some of the respondents claimed that they liked mathematics because they enjoyed the problem solving aspect of mathematics. They believed that mathematics is logical in nature, besides having a power of certainty (such as getting the right answers). Implicitly, these reasons reflected the respondents' views about mathematics, in particular the problem solving and the absolutist or dualistic view of mathematics.

In spite of finding some mathematical problems difficult to solve, some respondents resorted this to a mental challenge. When they obtained the right answers or solutions to problems, they found great satisfaction and reward. In terms of attribution theory, this might be explained as these respondents attributed the difficulty of mathematics to the needs for more effort. When they succeed, they feel rewarded and satisfied, as well as pride in their achievement.

In contrast to those who reporting liking mathematics, those who expressed a dislike of mathematics tended to feel a lack of ability to learn mathematics and this may have elicited a feeling of incompetence. They tended to compare with others and believed that mathematics is only for the clever ones. This tendency seems to indicate that these respondents attributed their failures to the lack of mathematical ability and subsequently they felt themselves to be incompetent in mathematics.

Similarly, those who reporting disliking mathematics found mathematics difficult to understand and some find it confusing. However, unlike those who reporting liking mathematics that took the difficulty of mathematics as a challenge, those who dislike mathematics tended to blame their failure or inability on their teachers. They tended to believe that they could not understand or that they got confused because they were not taught properly or they had been badly taught.

These findings show that instead of attributing to a lack of effort, those who dislike mathematics seem to attribute their failure in mathematics to lack of mathematical ability and lack of support from others (in particular, their mathematics teachers). They appear to exhibit some of the behaviours of students suffering from the learner-helplessness (as described by Diener & Dweck, 1978; Kloosterman, 1984). According to these studies, these students tended to focus on the cause of failure and attributed their failure to the lack of ability.

7.3 Possible factors of influence

The discussion in the following section draws mainly from the analysis of the qualitative data, which aims to explore the possible factors of formative influence on adults' images of mathematics. The results highlighted five main possible factors of influences: (a) mathematics learning experience in school, (b) personalities and teaching styles of mathematics teachers, (c) parental influence [mostly father], (d) a person's own interest in mathematics, and (e) peer influence. There were significant differences in the nature and degrees of influence of these factors between those who reported liking and disliking of mathematics. Table 7.4 presents a comparison and summary of the characteristics of these factors of influence between these two groups.

(a) School learning experience

Mathematics learning experiences in school, especially the negative ones seem to have prominent influence on the respondents' image of mathematics. Most respondents who reported a disliking of mathematics still recalled vividly their painful and frustrating experience of learning mathematics in school.

> That was when I was at O-level. I just found all of it too hard, you know. I tried really hard but I still got the wrong answers.
>
> (R268, text-unit 31, a nurse, 21-30, female, dislikes maths)

> That was 13-16 and I was 42nd in the class of 42 with this subject, and the teacher would just said, "you know, you go like this, and the resultant of forces like that, we see that, don't we?" And I did not. And I feel that being a 42nd in the class of 42 is not a good feeling [laughter]. And I felt bad about that.
>
> (R399, text-unit 15, musician, over 50, male, dislikes maths)

On the other hand, for those who reported a liking of mathematics, their mathematics learning experiences in school were characterised by enjoyable, challenging and revealing experiences.

> It was looking at loci, actually-path of a point. It was when my teacher went down and took it exactly along the bottom of the borders, tracing the point of the path on a circumference, watching the path and that's when I realised that there was mathematics in the most simple thing that you can look at that. It is the very first time I realised that, you know. But there is just more than adding, subtracting and multiplying the numbers.
>
> (R286, text-unit 17, mathematics teacher, 41-50, female, likes maths)

Thus, a comparison between these two distinct groups might help to further illuminate the influence of school experience on these respondents" attitudes to mathematics and subsequently their images of learning mathematics. As I have analysed and described the mathematics learning experience of these two groups in chapter 6, I will only summarise and discuss their prominent differences here.

First of all, not all respondents who reported a liking of mathematics had positive experience of learning mathematics in school from primary to secondary. Only 14 out of the 36 interviewed claimed that they enjoyed learning mathematics all through primary to secondary schools. Similarly, for those who reported a dislike of mathematics, only 6 out of the 26 interviewed claimed that they did not enjoy learning mathematics at all from primary to secondary school.

These results suggest that the majority of the sample enjoyed positive experiences of learning mathematics at some stages of their school lives, whether they reported liking or disliking of mathematics.

Secondly, both groups seem to experience primary mathematics learning as fun-based, easy and enjoyable. In fact, some of those who reported liking of mathematics found primary mathematics and even secondary mathematics too simple and basic, and thus it was not enjoyable or challenging enough for them.

However, both groups seem to experience learning mathematics at upper secondary, GCSE and A-level mathematics as becoming more and more difficult. This seems to be the deciding stage where these two groups divide themselves. For those who reported liking of mathematics, they enjoyed the challenge of solving higher level of mathematics. In contrast, those who reported a disliking of mathematics struggle through but many of them felt frustrated and gave up mathematics at higher level.

In summary, these results indicate that prior experience of learning mathematics such as at primary and lower secondary level might have influenced a person's motivation to continue to learn mathematics at higher level. However, it is at higher level such as at GCSE or A-level that are the more important determining levels. At these levels, those who previously like mathematics might find it too difficult or irrelevant and changed their attitudes towards it. Similarly, there are also those who suddenly realised or recognised the importance and the beauty of mathematics at these levels, normally with the help of inspiring mathematics teachers and they changed their attitudes towards mathematics. Thus, indirectly, these results suggest that secondary mathematics teachers, in particular, might have played an important role in determining a student's interest or motivation in learning mathematics. Of course, due to the nature of the sampling in this study, the latter claim remains speculative without further evidence.

(b) Mathematics teachers

Mathematics teachers, particularly in terms of the impact of their personalities and teaching styles were quoted by many respondents in this study as one of the most salient determining factors for their liking or disliking mathematics, and subsequently their choices of taking up higher level mathematics (or not).

> I think, teacher has an enormous influence... I think it is very easy to be put off by mathematics, as you know, mathematics is too difficult. It is easy or seen as an obstacle for a student if that happen earlier on, the choice like between the

> humanities and science. If you are not seen as a mathematics student, then it is very easy to lose confidence in maths.
>
> (R220, text-unit 21, speech and language therapist, female, 41-50, likes maths)

In addition, both of those who reported liking and disliking of mathematics tended to relate their positive and negative experience of mathematics learning to their mathematics teachers. The majority of those who reported a liking of mathematics claimed that they had had mathematics teachers who were encouraging, inspiring and enthusiastic. They claimed that their mathematics teachers were able to make mathematics learning interesting and easy to understand because their explanations were clear and simple. This is illustrated in one of the interviews with a psychology student,

> R547: My teacher made mathematics a very enjoyable subject. They made it very relevant to parts of life. It was not just simply numbers. It was very much a practical subject. And the teachers themselves were very approachable as well.
>
> I: Do you mean your mathematics teacher was very inspiring too?
>
> R547: Yes, that's right. Almost everyone in my class was really really enjoyed mathematics.
>
> I: Was your teacher teaching in whole class or individualised learning?
>
> R547: No, it included everyone but gave time to individual who needed it, with a very personal technique of teaching for everyone.
>
> (R547, text-unit 11-15, psychology student, female, 21-30, like maths)

Her description indicated three characteristics of a mathematics teacher of which commonly occurred among those who reporting liking mathematics:

- active and enjoyable teaching approaches;
- inspiring and approachable personality; and
- giving adequate attention to every student.

In contrast, about half of those who reported a disliking of mathematics attributed their failures in mathematics partly to their mathematics teachers. A student adviser who reporting disliking mathematics described her experience of mathematics teacher as follows:

> She concentrated very much on those who could do maths. And there was one girl in our form who was absolutely brilliant at it and she focused on her the whole time. If you asked a question because you didn't understand it, it was told you again. But it wasn't explained, it's just re-told. It was just re-repeated. If you didn't understand it in the first time, by just re-repeating it doesn't mean that you are going to understand it the second time. And I just got bored. I just thought, "oh! Fine, I don't like this". It is not for me.
>
> (R115, text-unit 10, a student adviser, female, 41-50, dislikes maths)

Similarly, her account highlighted some characteristics of mathematics teachers that were commonly claimed by those who reporting disliking mathematics such as:

- did not explain well
- did not give enough attention or encouragement
- biased and tended to give more attention to their peers who were already better in mathematics

There were 10 respondents who reporting disliking mathematics complained that their mathematics teachers' teaching approaches was very passive and boring while seven of them claimed that they were not taught properly as a child.

> …what I am trying to say is when I was in school, the way the teacher ...[pause a while] taught is boring and hard to get the class interest. They gave you this book where you have to sit down and do it. And ... that was it really. (R496, text-unit 31)
>
> I think it is the way that you were taught in the early age. If it was not made interesting from the start, then as you go on, you just don't enjoy it. (R496, text-unit 63)

As a result, many of them claimed that they felt frustrated and lost their interest in mathematics.

Likewise, the claim for 'proper' or 'right' method of teaching approach was also evidenced as part of four respondents' answers to the open-ended question asking for their image of learning mathematics. For example, learning mathematics is

> fairly easy if taught right (R308);
>
> could be very good if taught properly (R399);
>
> a pleasant mental exercise-providing it is well taught in appropriate steps (R475);
>
> interesting if taught the right way (R502).

All these responses highlighted the important role of teaching approach in the adults' experience of learning mathematics in school. This is especially prominent in those who reported a disliking of mathematics. Even though there is no direct correlation between these adults' image of mathematics (and learning mathematics) and their experiences of mathematics teachers, the difference in experience of the latter could have an influence on their attitudes towards mathematics (in particular their reason for liking or disliking mathematics), and consequently their choice for taking up further mathematics (or not). The findings of this study, thus, partly concur with the results of past studies (McSheffrey, 1992; Brown, 1992). McSheffrey found that his women subjects' experiences with their mathematics teachers were prominent in their reasons for avoiding mathematics. Likewise, Brown's study suggests that different teachers with different teaching approaches have resulted in different images of mathematics for their pupils.

Table 7.4: A comparison of the characteristics of five major factors of influence between those who reported liking mathematics and those who reported disliking mathematics

Major factors of influence	Respondents who reported a liking of mathematics	Respondents who reported a disliking of mathematics
Mathematics teachers	explain well active teaching style make learning interesting and enjoyable inspiring and encouraging a lot of patience give individual attention/time good rapport with students	poor explanations given passive teaching style authoritarian or teacher-centred teaching style discouraging and humiliating lack of patience biased, giving more time to the clever ones poor rapport with students
Parents	encouraging valuing mathematics tutoring at early age or primary school (mostly given by father) playing games with mathematical content	negative attitudes towards mathematics little or no tutoring at early age or primary school discouraging because of low expectations
Own self	Confident about self in mathematics 'good at it' positive attitudes towards mathematics enjoy learning and doing mathematics	low self-esteem re mathematics feel incompetent negative attitudes towards mathematics exhibit strong negative feelings about mathematics
Peers	Mathematics competitive at primary school but co-operation and collaboration at secondary or higher level	mostly dislike mathematics or anti-maths
Mathematics learning experience in school	Primary level: slightly more positive than negative Secondary level: mostly positive Tertiary: mostly positive	Primary level: slightly more negative than positive Secondary level: mostly negative Tertiary: never reach this level in mathematics

(c) Parents

Past research (Cain-Caston, 1986; Parson, Alder, & Kaczala, 1982; Wigfield, 1983; Yee et al., 1984, 1986; Dickens and Cornell, 1990; Reilly et al.,1992; Cai, Moyer and Wang, 1997) suggest that parents' attitudes towards mathematics, parents' expectation and beliefs about their children's mathematical abilities as well as parental support are related to their children's attitudes towards mathematics and their mathematics achievement. However, in this study, the findings suggest that these influences only had a limited impact.

Instead, from what has been espoused by the respondents, parental influence was given in the forms of: (detailed analysis was given in Chapter 6)

- Encouragement and motivation
- As a role model for a good mathematician
- Initial tutoring at early age or primary school and
- Attitudes towards mathematics, including valuing the importance of mathematics.

Between parents, fathers seem to be more influential than mothers, particularly as a model of a good mathematician.

> "Hmm, influenced by my …teachers but it started way before that, it was influenced by my parents, my father in particular. He was an engineer and therefore he enjoyed maths. Therefore I did mathematical problems from a very early age. So, when I went to school, it was just an extension. So I think my mathematics teacher has a relatively easy drive.
>
> (R491, text-unit 25, 51-60, IT engineer, male, like maths)

Although this similar influence might prove to have negative impact on others, such that

> R513: I couldn't get on if people were sarcastic. I thought it might have to be because my father was, you see. And he was... he could make you feel very small. Because he was a perfectionist and then if you didn't come out to [be] his standard. So, I was already.. you know…
>
> I: Is your father very good at mathematics?
>
> R513: Hmm, I think he was quite good, probably.
>
> (R513, text-unit 49-51, over 50, retired lab technician, female, dislike maths)

The above description about parental support and motivation was more likely espoused by those who reporting liking mathematics than those who reporting disliking mathematics. Although the latter might have described their parents as supportive and encouraging, most of them claimed that they received little or no help from their parents. The reason could be their parents were too busy at work:

> When I was little, if anybody in my family said, "oh, this is very important and things like that, then I would be, you know. But just because my mum is sort of busy and things like that, so ...
>
> (R267, text-unit 19, 31-50, housewife, dislike maths)

Sometimes their parents evidenced little interest in mathematics.

> Interviewer: Do you think your view of mathematics might have been influenced by anyone at home
>
> R544: No, no one at home at all. No one at all at home.
>
> Interviewer: Your parents?
>
> R544: No, not in any way. Because I can say that quite clearly because they didn't see the need to encourage me to want to take mathematics further. As far as they were concerned, their attitude was once I was 16 or 17, I should be working, I shouldn't be going on to the higher education. Because it would cost a lot of money etc etc etc, so I never did. And I have to come for that later in my life.
>
> R544, text-unit 29-32, 51-60, Primary teacher, male, like maths)

Others felt that they were following the footsteps of their parents because the parents themselves also showed little interest in mathematics and were not confident in their own mathematical abilities.

In summary, at least for this sample, parental influence was seen to be most prominent in the early stages of learning mathematics. Parental support (most likely father) was experienced more by those who reporting liking than those by those reporting disliking mathematics. This finding partly echoes what has been found by Rooney (1998) where she observed parental support has an impact on her five adults respondents' perceptions of mathematics.

(c) Peers

In comparison with other factors discussed above, peer groups seem to offer relatively less influence on adults' images of mathematics. Only one quarter of the interview sample mentioned the influence of peers in their mathematics learning experience in school. As expected, those who expressed a liking for mathematics tended to be friends with others who share an interest in mathematics. At primary school level, their peers acted as a source of healthy competition while at higher level, such as A-level, they acted as a supportive group.

Whereas for those who expressed a dislike of mathematics, they found their peers to have problems in mathematics also, and some even exhibit 'anti-maths' views as described by a young ecologist,

> When I was at school, whenever I have difficulty, we all can't really help each other. If anything, I did better than them as I could get help from my dad at home. I think we all pretty anti-math altogether.
>
> (R025, an ecologist, female, 21-30, dislikes mathematics, text-unit 45)

Thus, peer influence could be either positive, when given in the form of encouragement and support, or negative, such as in the reinforcement of negative attitudes towards mathematics. Interestingly, Rooney (1998) also observed similar peer influences in her study on five adults' perceptions of mathematics.

(e) Own self

Besides the above external factors (mathematics teachers, parents and peers), some respondents claimed that they themselves are to be credited or blamed for their success or failure in mathematics. Analysis of the interviewed sample suggests that 27.8% (f=10) of those who reported a liking of mathematics credited their success in mathematics and positive attitudes towards mathematics to their own interests and self-motivation in mathematics. On the other hand, 26.9% (f=7) of those who reported disliking of mathematics blamed their own lack of mathematical ability and interest for their failure in mathematics. These results are interesting because they seem to support Hoyles' (1982) studies on 14-year-olds, where she found that self-factor was stressed in both good and bad stories of mathematics experience. Perhaps, this is not a surprise if the majority of the respondents in this study tended to believe that mathematical ability is something that you have or have not.

7.4 Comparisons between gender, age and occupational groupings

Image is a personal construct, and it consists of fragments of past affective and cognitive experiences (Thompson, 1996a). It follows that the characteristics of a person's image of mathematics might be distinguished more by differences in mathematics learning experiences of each individual, coupled with the impact of the influence of significant others such as teachers, parents and peers, rather than as a function of the individual's gender, age or occupational differences. In the following, I discuss and compare the differences and similarities that have been observed in both the quantitative and qualitative data of the study.

Between genders

On the whole, the findings of this study both challenge and support the widespread claim in the literature that women exhibit more negative images of mathematics then men do. First of all, there was no significant difference observed between men and women of this sample in their reported liking and images of mathematics. This challenges the above claim. However, the women expressed significantly more negative feelings towards learning of mathematics than the men did. There were 10-13% more women than men who expressed the view that they were unsure, worried and nervous when they thought of learning mathematics in school. The latter seem to echo the findings in the literature that "girls are more mathematics anxious than boys" (Gutbezahl, 1995).

Secondly, among those who reported a disliking of mathematics, the female respondents tended to attribute their dislike or failure in mathematics to their own lack of mathematical abilities, whereas the male respondents attributed the causes of their failure to others (in particular, their mathematics teachers). This finding seems to confirm the claim that there is a gender difference in causal attributions of success and failure in mathematics (Weiner, 1983, Leder, 1992b). Implicitly, this result suggests that the women, having lower perceived confidence in mathematics (Vermeer, Boekaerts, & Seegers, 1997 and Burton, 1989) tend to blame themselves rather than others for their failure in mathematics.

Thirdly, more men than women respondents believed that their attitudes towards mathematics were more influenced by their parents than their peers or by societal views of mathematics. This result concurred with findings in the literature that since most parents have higher expectation of their sons' ability in mathematics, boys tended to receive more parental support than girls do. Not surprisingly, it thus follows that girls, who tended to receive less attention and lower expectations of success from their parents, peer groups and social attitudes (Jacobsen, 1985), are led to believe that mathematics is a male-domain and also tend to belittle in mathematical abilities. Consequently, the females were more easily influenced by their own society's views and that of their peers.

Nevertheless, many of these female respondents claimed that they have changed their attitudes towards mathematics since they left school. Some have gained confidence in using mathematics because they have mastered their mathematics in daily use while others have also used mathematics successfully in their jobs. This change of attitudes might partly explain why there is no observed significant difference between the genders in the reported liking of mathematics.

Among age groups

Among the four age groups studied, the young peoples (aged 17-20 years old) seem to display the most negative images of mathematics. In terms of reported liking of mathematics, the young people group (17-20) has the lowest percentage, just over 40% while the middle-aged group (31-50) has the highest, almost 60%.

In addition, there was a trend that the younger the age group, the stronger the feelings of 'boredom' associated with mathematics. 38% of the young peoples responded that they were or had been bored by mathematics, whereas only 15-16% of the older age groups (over 30 years old) expressed this view. In addition, the young people group tended to show the highest percentage in other negative feelings such as 'unsure' and 'worried' than the other older age groups, except for 'confused' (slightly lower than the oldest age group of over 50).

Across all age groups, the majority of the sample seems to indicate the importance of school mathematics as closely related to its utilitarian aspect and attach less importance to the appreciation of its societal and cultural values. This view is most strongly held by the young people group. Thus I speculate that this might be a possible reason for many young peoples to have negative image of mathematics or to dislike mathematics. Because without realising and appreciating the cultural and societal importance of mathematics, a mere emphasis on the utilitarian aspect of mathematics might not be enough to sustain pupils' interests or to develop deep appreciation of mathematics.

This speculation is confirmed to some extent by the interview data. When the interview sample (N=62) were asked for reasons for liking mathematics, no one from the young people group (n=12) stated any of their reasons as appreciating the beauty of mathematics. In contrast, four out of 17 of the young age group (aged between 21-30 years old) and three out of 21 of the middle age group (aged between 31-50 years old) quoted the beauty of mathematics as one of their reasons for liking mathematics. However, these responses are so few that no firm conclusion can be reached.

Since the young people group was the one that exhibited the most dislike of mathematics, they also displayed most of the characteristics of those who dislike mathematics. For example, they tended to believe that mathematics was more for the clever ones and they themselves were lacking in this mathematical ability. However, for the young people group who reporting liking mathematics, they espoused the view that learning mathematics is a mental challenge that gave them a sense of satisfaction.

In contrast, the middle age group showed the most positive attitudes towards mathematics and displayed higher intrinsic motivation in learning mathematics than the younger age groups. They gave their reasons for liking mathematics as they were 'good at it' (expectancy) and 'can use it' (value). However, their most common reason for dislike of mathematics was related to their mathematics teachers. They commonly attributed the cause of their failures to their mathematics teachers such as

> Hmm, we did not have a very good mathematics teacher at school and that put me off for liking it.
>
> (R115, text-unit 8, age group 31-50, student advisor, dislikes maths, female)

> When I think back when I was at school. Maths was never taught to us, you know, in a thoughtful way. It was always difficult and the maths teacher…
>
> …I think I hardly have any respect of my maths teacher because I don't think they were teaching me in a way that I could understand…
>
> (R218, text-unit 7 & 9, age group 31-50, mental health professional, female, dislikes maths)

Another interesting and significant difference (significant at 0.05 level using the Chi-square Test) was observed in the view about gender differences in mathematical ability. The young people group (6% more than all the other age groups) espoused the belief that mathematics is a male domain, while the older age group (aged over 50 years old) had the lowest response in agreement with the claim that both genders are similar in mathematical ability. This finding seems to suggest that the young peoples and the olds exhibit similar beliefs about mathematical ability with reference to gender differences. This is surprising because we would have expected that after the move to greater equal opportunities in education for both males and females in the 1980s, the younger age groups would not share the same view of mathematics as a male domain as the older age group. However, due to the use of opportunity sample, I acknowledge this finding might limit itself to only this sample, and might not be generalisable to include the general public at large.

In brief, the significant difference in images of mathematics among the age groups do give rise to concerns about the fact that the young people group has the most negative images of mathematics. The young people group which most of its members was still studying in universities and was also those with the freshest memories of learning experience in school, so what is the reason that they exhibit such a negative image of mathematics? What does this imply for our contemporary mathematics education in school? Moreover, these young peoples representing the future workforce and so a majority of them (59%) reporting a dislike or uncertainty in liking mathematics, this result is disturbing and worrying. Although I acknowledge that there might be sampling errors because the sample collected was an opportunity sample, the significantly higher percentage of disliking among the young people group thus points to the need for further research into the possible causes of these young peoples' images of mathematics.

Among different occupational groupings

Due to difference in the nature of occupations, mathematics qualifications, and the degree of involvement in mathematical activity in work and daily life, it is reasonable to expect that people from different occupational groupings might exhibit different images of mathematics. Inevitably, mathematics teachers and mathematics students are expected to have more positive images than the others do since they have the most involvement with mathematics following their positive free choices. Similarly, professionals are those with higher qualifications in mathematics and most likely to use mathematics in their careers, and thus most likely to have a more positive image of mathematics than lower social class respondents. However, this result was a surprise.

In fact, five general trends emerged from the analysis of both quantitative and qualitative data, linking social class (by occupation) to the sample's images of mathematics. Detailed analysis was provided in chapters 5 and 6. Here I will only summarise and discuss the most striking findings.

First of all, there was an increasing trend of reported liking of mathematics from the lowest to the highest social class by occupation. The professionals seem to like mathematics the most (over 70% reported liking) but the unemployed and others the least (under 40%). Likewise, there was a striking disparity between the disliking of mathematics as reported by the professional subgroup and the skilled subgroup, with reported dislike being almost three times more prevalent among the latter (44.4%) than in the former (15.9%).

The latter result is unexpected because it is supposed that many skilled workers use mathematics in relation to their work, and that this might lead to more positive reported attitudes. Although, in contrast, one might reasonably suppose that the higher levels of occupation would have had more success in school examinations (including mathematics), and would have higher qualification in mathematics. Subsequently the higher social class might have more positive attitudes towards mathematics than the lower social class. Therefore, the result indicates that frequent use of mathematics in one's work might not necessarily lead to a more positive attitude towards mathematics.

Secondly, it is disturbing to observe that non-mathematics students reported the lowest scores in the reported liking of mathematics (49.6%) as compared with all the other occupational groupings. In fact, this score is slightly lower than the score for the whole sample (53.9%). This finding is a matter of concern, especially since the sample size of the non-mathematics students is moderately large (n=117), so it may be taken to be representative of the population at least in part. Non-mathematics students constitute the overwhelming majority of students, and this group represents the future human resources of the nation, so if half of this grouping dislike mathematics, as in this sample, this is a worrying result. Moreover, these results seem to suggest that there appear not much improvement in attitudes to mathematics among the UK adults since the study of Sewell (1981). The young generation seems to have more negative attitude to mathematics than the older generation, at least in this sample.

Thirdly, there was also a general trend of the higher the social class (by occupations), the more positive expressed feelings they had when they thought of learning mathematics in school. While the expressed feelings of the professionals, mathematics teachers and mathematics students skewed significantly towards positive descriptors, such as being interested, confident and finding mathematics enjoyable, the non-mathematics teachers' and non-mathematics students' expressed feelings skewed significantly towards the negative feelings, such as being confused, unsure and worried. However, more than one third of the professionals also expressed feelings of being confused. In fact, this percentage was slightly higher than the percentage of the social class II (the managerial and technical) and the social class IV (the unskilled workers).

Moreover, the interview data indicate that not all the professionals experienced positive feelings of learning mathematics in school. This led me to speculate that, in spite of negative mathematics learning experience in school, these respondents' attitudes towards mathematics could have changed due to career needs or maturity in thinking. Another argument could be that negative feelings experienced by some people might not have deterred them from liking mathematics.

Fourthly, the mathematics teachers and mathematics students were the two dominant groups who presented their images of mathematics and learning mathematics in terms of values in mathematics or education, such as the beauty of mathematics. Likewise, the professionals and the managerial subgroup tend to link their images of mathematics to values in mathematics or education, slightly more than the other occupational subgroups.

Fifthly, the results indicated that occupational experiences could have some influence on people's beliefs about the nature of mathematics and consequently their views about mathematics. For instance, both the mathematics teachers and mathematics students were among those who have had direct involvement with mathematics. More seem to hold a fallibilist view (Ernest, 1991) of mathematics than any of the other subgroups. They are the group who most espoused the view that there are constantly new discoveries in mathematics, but also the group who least reflected the view that mathematics is made up of rules and procedures which is certain and exact. In contrast, most members of the managerial and technical subgroups seem to hold a more absolutist or dualistic view of mathematics. They tended to agree that mathematics is a collection of rules and procedures and mathematical knowledge is certain and exact.

Lastly, significant variations among the occupational groupings implied that careers or social class are correlated with people's belief about gender differences in mathematical ability. The teachers were the groups who most believed that both genders have equal ability in mathematics. But the professionals and the non-mathematics students were the two groups who most believed that mathematics is a male dominant subject.

In summary, these finding show that career differences and the degree of involvement with mathematics might impact on a person's images of mathematics, particularly in terms of liking, positive expressed feelings, beliefs about the nature of mathematics and gender differences in mathematical ability. However, while the negative experience of learning mathematics in school might have deterred most people from liking mathematics, this is not always true for a few others (particularly, the professionals and the mathematics teachers).

7.5 Summary of chapter 7

This chapter synthesised the results from both stages of the study, including both quantitative and qualitative data collected. Although most respondents subscribe to more than one view of mathematics, there appear to have at least five commonly shared views: utilitarian, symbolic, problem solving, enigmatic and absolutist or dualistic view. Likewise, there is no direct correlation between the different views and the experience of learning mathematics. However, the differences in the reasons for liking or disliking mathematics highlighted the possible influence from mathematics learning experience in school and the significant others (such as, mathematics teachers and parents). Moreover, a comparison between the different gender, age group and occupational groupings suggest that there are some differences as well as similarities between these subgroups.

To sum up, the findings of this study seem to both support and challenge findings in the literature with regard to gender difference in attitudes to mathematics and mathematical ability, as well as the prominent influence of mathematics teacher in students' mathematics learning experience and possibly their images of mathematics. However, there is also past studies (see e.g., Ryckman and Mizokawa, 1988; Chen and Stevenson, 1995; Huang and Waxman, 1997) that highlighted the difference in cultural beliefs and values might have impact on students' attitudes to mathematics. Thus, it might be beneficial to investigate whether the difference in cultural beliefs and values might have also impact on adults' images of mathematics. This is where I shall turn to now, in the following chapter, to compare and discuss the possible influence of cultural difference in some students' and teachers' images of mathematics, based on the data collected in a sub-study.

Chapter 8

A comparison between Malaysian and United Kingdom teachers' and students' images of mathematics

This chapter reports and discusses the findings of a cross-cultural study that aims to explore images of mathematics of a sample of Malaysian teachers and students. This cross-cultural study was carried out as a sub-study of the overall study. First, I describe the aims, the sample and the methods used for data collection of this cross-cultural study. Next, I discuss the results in comparison with that of the teachers and students in the United Kingdom sample.

8.1 Aims of this cross-cultural study

In exploring images of mathematics of a sample of the adult members of the UK public, I was surprised to find that there was a widespread negative image of mathematics among the UK public, especially among the youths and the non-mathematics students. I believed it would be interesting and beneficial for me to explore images of mathematics of the Malaysian public, my country of origin, in order to compare these two samples. However, as Malaysia is still a developing country, the school attendance and literacy level of its general public is probably not comparable with that of the UK general public. The educational statistics of Malaysia shows that the school enrolment rate at all levels was 70% in 1978 (Malaysian Ministry of Education, 1982) and the school enrolment rate (up to lower secondary) was 83% in 1994 (Malaysian Ministry of Education, 1996). Although the primary school enrolment rate was reported as 99% in 1997 (Economic Planning Unit (Malaysia), 1998), the adult population that has studied secondary mathematics was still incomparable with those of UK. This is because 100% of the UK public adults receive compulsory education till the age of 16 years old. The samples might, therefore, not be comparable if I were to do a cross-cultural comparison study between the adult members of the general public of these two countries. (Detailed statistics of the Malaysian school enrolment rate is given in Appendix L).

However, the Malaysian education system, in particular its mathematics education, shares a very similar structure in terms of curriculum contents. This may partly be due to the historical and colonial link between the two countries. Therefore, it seems reasonable for this cross-cultural study to make a cross-cultural comparison on images of mathematics between a sample of teachers and students in Malaysia and in UK, hence focussing only on comparable population segments of both countries. In other words, this cross-cultural study aims to explore any cultural differences in images of mathematics between the samples of teachers and students in the two countries.

8.2 Research questions of this cross-cultural study

In particular, this cross-cultural study aims to answer the following research questions:

1. Is there any difference in images of mathematics between teachers of Malaysia and UK?
2. Is there any difference in images of mathematics between students of Malaysia and UK?
3. Are images of mathematics universal and similar in both cultures?

8.3 Method

Consistent with the main study, the image of mathematics was defined in similar terms and the same methodology was used for this cross-cultural study. Due to constraint in time and resources, the data was only collected using the short questionnaire similar to the one used in stage one of the main study.

Some modifications on the questionnaire were made to suit the need of the Malaysian sample. Firstly, the questionnaire was translated into Bahasa Malaysia, the official language of Malaysia. This is also the medium of instruction in all Malaysian government-owned educational institutes.

Secondly, two items of question 3 on expressed feeling toward learning mathematics in school were initially changed from 'cold' to 'takut' (afraid) and from 'certain' to 'susah' (difficult). This was because there is no equivalent expression of these two words in Bahasa Malaysia. The word 'cold' can only literally translated to 'sejuk', which carries the meaning of coldness due to low temperature. The word which is available and closest in meaning with the word 'cold' is 'takut' (or afraid). This word is also more commonly expressed by the Malaysian as one of their feelings towards mathematics learning. Similarly, the word 'certain' if literally translated into Bahasa Malaysia will be 'pasti' and it carries the similar meaning as 'yakin' (confidence). Therefore to tap the more commonly expression for feelings of the Malaysian sample, I proposed to use the word 'susah' (difficult).

However, during the analysis phase, these two items were discarded. This was because I acknowledge that the translated version of 'takut' for 'cold' and 'susah' for 'certain' may carry different meanings. These two items, therefore, may fail to reflect the intended or similar meaning of these words (as used in the English version). Thus, if these two items were included in the analysis, the results obtained would not be properly comparable between the two languages and countries.

The questionnaire was first translated by me and then validated by two Malaysian research students (specialising in English language) to ensure that the translated copy was as equivalent as possible in content and meaning to the English version. The translated version of the questionnaire is given in Appendix M.

8.4 Sample

A total of 100 teachers and 306 students in Malaysia responded to the questionnaires. Table 8.1 displays the frequency distribution of the sample in terms of gender and occupational groupings. The teacher sample was collected from two teacher-training colleges where these teachers were attending an in-service course. All these teachers were qualified primary school teachers. 36 of them were mathematics specialists while 64 of them specialised in English or science. Similarly, the student sample was collected from the same teacher-training colleges. These students were attending a two-year full-time course in teacher education. 173 of them were majoring in either primary mathematics or secondary mathematics while 133 were majoring in English, science or other general subjects.

Table 8.1: Frequency distribution of the Malaysian sample

It is a common Malaysian phenomenon to have more females than males in teacher training colleges as well as in school. As displayed in Table 8.1, the frequency distribution in terms of gender thus reflects this situation in the Malaysian teacher-training colleges and schools.

8.5 Results and findings

The data collected was analysed in a similar manner as the main study. To assist in the comparison, I first selected out all cases (or records) of the teachers and students of the UK sample. Thus, I have two data files - one for the UK teachers and students while another one for the Malaysian teachers and students. I then ran the same statistical analysis on both data files.

However, for the open-ended question on images of mathematics and learning mathematics, all responses of the Malaysian sample (except 53 of them in English) were given in Bahasa Malaysia. I first translated all these responses into an English version before categorising them. The examples given in the following sections are verbatim responses that have been translated into English version. I used the notation, 'M000' to denote response of the Malaysian sample while 'R000' for response of the UK sample (where the three zeroes indicate where 3-digit response numbers are inserted).

For brevity, from now on, I shall refer the teacher and student sample from Malaysia as 'the Malaysian teachers and students'. Similarly, the UK sample of teacher and student will be referred as 'the UK teachers and students'. However, I acknowledge that as these samples were collected by opportunity and thus not representative, and all results and findings discussed below are limited and not generalisable to include the wider population of students and teachers of these two countries.

In the following section, I describe and compare the results of the analysis between the teachers and students of the two countries. There are seven subsections:

I. reported liking of mathematics,

II. expressed feelings towards learning of mathematics,

III. images of mathematics and learning mathematics,

IV. espoused beliefs about mathematical ability and gender differences in mathematical ability;
V. views about the importance of school mathematics,
VI. beliefs about the nature of mathematics and
VII. Images of mathematicians and their work

I. Reported liking of mathematics

Table 8.2 displays a comparison of reported liking and disliking mathematics between the Malaysian and UK teachers and students. Overall, 22.7% more of the Malaysian teachers and students reported a liking of mathematics than the UK teachers and students. Conversely, 25.5% more of the UK teachers and students reported a disliking of mathematics than their Malaysian counterparts. These results indicate that there were more Malaysian teachers and students claimed to like mathematics than the UK teachers and students.

Table 8.2: Reported liking of mathematics among Malaysian (and UK) teachers and students

In addition, a similar trend was observed between the samples from both countries that the mathematics teachers and students reported a higher percentage of liking mathematics than that of non-mathematics teachers and students. Perhaps this trend was not surprising because mathematics teachers and students were expected to have more positive attitudes to mathematics since they chose to specialise in mathematics. However, there was a striking difference in the reported liking and disliking mathematics between the non-mathematics students from both countries. The percentage of Malaysian non-mathematics students reporting liking mathematics was 32% higher that that of their UK counterparts. While 49.6% of the UK non-mathematics student reported a disliking of mathematics, only 9% of Malaysian non-mathematics students reported similarly. These results indicate that the UK non-mathematics students reported a comparatively higher percentage of disliking mathematics than their Malaysian counterparts.

In brief, these results suggest that the Malaysian teachers and students displayed a relatively more positive attitudes towards mathematics than their UK counterparts. Of course, this data must be treated with caution because there may be cultural differences with regard to the expression of opinions.

II. Expressed feelings towards learning of mathematics

When the sample were asked to express their feelings when they thought of learning mathematics in school, some interesting results were observed. Table 8.3 displays a comparison of expressed feelings towards learning of mathematics in school between the Malaysian and UK teacher and student samples.

Firstly, in comparison between countries, the Malaysian sample tended to indicate relatively higher percentages in positive feelings, in particular the feelings of 'interested', 'enjoyable', 'confident', 'happy' and 'relaxed', than the equivalent subgroups of the UK sample. This result suggests that the Malaysian sample might have enjoyed a more positive experience of learning mathematics in school than their UK counterparts.

Secondly, in terms of expressed negative feelings, I was rather surprised to observe a reverse trend. More Malaysians expressed negative feelings of 'confused', 'unsure' and 'worried' than their UK counterparts. Even among the Malaysian mathematics teachers, about 28% of them expressed negative feelings of 'confused' and 'unsure' but only less than 7% of the UK mathematics teachers shared these two feelings. This result indicates that even though the Malaysian sample might have expressed more interest and enjoyment about their mathematics learning experiences in school, they seem to experience relatively more negative feelings of confusion, worry and uncertainty than the UK sample. In addition, the UK mathematics teachers seem to express more feelings of 'confident' and 'relaxed', and comparatively expressed less feelings of 'confused', 'unsure' and 'nervous' than their Malaysian colleagues.

Table 8.3: Expressed feelings towards learning of mathematics among Malaysian (and UK) teachers and students

	Malaysian teachers and students (UK teachers and students)				
Positive feeling	Maths teachers n=36 (n=29)	Other teachers (non-maths) n=64 (n=38)	Maths students n=174 (n=47)	Other students (non-maths) n=133 (n=117)	Total sample N=407 (N=231)
Interested	88.9% (86.2%)	54.7% (50.0%)	91.4% (72.3%)	64.7% (46.5%)	76.7% (57.1%)
Confidence	61.1% (69.0%)	32.8% (18.4%)	59.2% (51.1%)	26.3% (25.4%)	44.5% (35.5%)
Enjoyable	80.6% (62.1%)	48.4% (26.3%)	86.2% (36.2%)	53.4% (20.2%)	69.0% (29.9%)
Happy	61.6% (58.2%)	26.6% (21.1%)	55.7% (27.7%)	34.6% (14.0%)	44.7% (23.8%)
Relaxed	41.7% (34.5%)	10.9% (13.2%)	43.7% (25.5%)	30.1% (8.5%)	33.9% (16.0%)
Secure	16.7% (37.9%)	7.8% (7.9%)	19.5% (27.7%)	15.0% (6.1%)	16.0% (15.6%)
Negative Feeling					
Confused	27.8% (6.9%)	54.7% (47.4%)	51.7% (21.3%)	64.7% (48.2%)	54.3% (37.7%)
Unsure	27.8% (3.4%)	50.0% (36.8%)	34.5% (19.1%)	46.6% (35.1%)	40.3% (28.6%)
Worried	13.9% (10.3%)	45.3% (50.0%)	27.6% (12.8%)	35.3% (29.8%)	31.7% (27.3%)
Bored	2.8% (6.9%)	15.6% (18.4%)	22.4% (10.6%)	27.8% (46.5%)	21.4% (29.4%)
Nervous	13.9% (6.9%)	34.4% (34.2%)	11.5% (6.4%)	18.8% (17.1%)	17.7% (16.0%)
Threaten	5.6% (6.9%)	32.8% (28.9%)	10.3% (6.4%)	24.1% (23.9%)	17.9% (19.0%)

Note: Figures in parentheses indicate results from the UK samples

On the other hand, the mathematics teachers and students from both countries displayed a similar trend in their expressed feelings towards learning of mathematics in school. They expressed noticeably more positive feelings towards mathematics than the non-mathematics teachers and students. Conversely, the latter expressed higher percentages in negative feelings than the former. As shown in Table 8.3, most of the results have observed differences, which suggest that these feelings were different within subgroups of each country.

Nevertheless, it is difficult to know how to interpret these results without further data. Perhaps a cultural difference is that the Malaysian sample might be more ready to subscribe to strong statements of opinion than the UK sample. However, without further data, this remains a speculation.

III. Images of mathematics and learning mathematics

As in the main study, I have categorised the images of mathematics and learning mathematics given by the Malaysian sample using the categorisation developed for the UK sample and shown in Figure 5.4 and Figure 5.5 (in Chapter 5). To assist comparison, I have ranked these subcategories according to the frequency of occurrence of responses, from the most common down. Tables 8.4 to 8.7 display the ranking of subcategories for each subgroup.

(a) Images of mathematics

There were striking differences as well as similarities in the images of mathematics given by both the Malaysian and UK samples. For the Malaysian sample, images of mathematics were characterised as a subject of study which is enjoyable and challenging, albeit difficult for some people. The image of mathematics was most commonly given as:

> an enjoyable and challenging subject (M134, non-maths student, female, 21-30);
>
> an interesting and challenging subject (M225, maths teacher, male, 31-50)
>
> a challenging but enjoyable subject (M324, maths student, female, 31-50)

Moreover, as displayed in Table 8.4, the next common image of mathematics given by the Malaysian sample (12.8%) was the view that linking mathematics to numbers and symbols. For example, mathematics is:

> calculation that involves numbers and figures (M112, non-maths student, female,17-20)

> an activity that involved numbers and precise calculations (M220, maths teacher, male, 21-30)

> a relationship between numbers and symbols (M322, maths student, female,31-50)

> a picture of numbers that need to be solved (M255, non-maths teacher,male,31-50)

Or involved mental thinking, such as mathematics is:

> a subject that need thinking (M172, maths student, female, 17-20)

> improve your mind to think precisely and accurately (M293, non-maths student, male, 21-30)

> a mind-testing subject that use a lot of creativity and is challenging (M041, maths student, female, 21-30)

Table 8.4: Images of mathematics of the Malaysian sample: list of the most common response categories

Malaysian teacher and student grouping				
Mathematics teachers (n=36)	Other teachers (non-maths) (n=64)	Mathematics students (n=174)	Other students (non-maths) (n=133)	Total sample (N= 407)
Challenging 30.1%(f=11)	Difficult 23.4% (f= 15)	Enjoyable 23.0% (f=40)	Enjoyable 17.3% (f=23)	Enjoyable 17.9% (f=73)
Interesting 19.4% (f=7)	Interesting 15.6% (f=10)	Mental work 16.7% (f=29)	Calculation 16.5% (f=22)	Challenging 13.5% (f=55)
Numbers and symbols 13.9% (f= 5)	Effortful endeavour 7.8% (f=5)	Challenging 15.5% (f=27)	Numbers and symbols 15.0% (f=20)	Numbers and symbols 12.8% (f=52)
Problem solving 13.9% (f=5)	Mental work 7.8% (f=5)	Numbers and symbols 8.6% (f=15)	Difficult 12.8% (f=17)	Interesting 11.3% (f=46)

?

In contrast, as shown in Table 8.5, more than 10% of the UK teachers and students expressed their images of mathematics as related to boredom and difficulty. For example, mathematics is,

> hard and difficult to understand (R094, non-math student, female, 21-30)
>
> really difficult and confused - like getting lost (R397, maths student, female, 17-20)
>
> boring, hard & very academic (R512, maths student, male, 17-20)
>
> difficult, unimaginative and dull (R64, history student, male, 17-20)
>
> difficult subject (R477, drama teacher, male, 31-50)

Particularly, these images of mathematics were most commonly espoused by the non-mathematics students aged between 17-20 years old from the UK sample. Table 8.5 shows that about 18% of them indicated that mathematics is 'boring' and 13% noted

Table 8.5: Images of mathematics of the UK sample: list of the most common response categories

UK teacher and student grouping				
Mathematics teachers (n=29)	Other teachers (non-maths) (n=38)	Mathematics students (n=47)	Other students (non-maths) (n=117)	Total (N=231)
Enjoyable 2.7% (f=6)	Difficult 13.2% (f=5)	Interesting 17.0% (f=8)	Boring 17.9% (f=21)	Difficult 11.7% (f=27)
Challenging 13.8% (f=4)	Problem solving 13.2% (f=5)	Difficult 14.9% (f=7)	Numbers and symbols 12.8% (f=15)	Boring 10.4% (f=24)
Games/puzzles 10.3% (f=3)	Pattern/ structures 10.5% (f=4)	Problem solving 10.6% (f=5)	Difficult/hard 12.8% (f=15)	Enjoyable 9.5% (f=22)
Rewarding 10.3% (f=3)	Challenge 10.5% (f=4)	Beauty of maths 10.6% (f=5)	Complexity 8.5% (f=10)	Numbers and symbols 9.1% (f=21)
Necessary 10.3% (f=3)		Challenging 8.5% (f=4)	Logical thinking 8.5% (f=10)	Challenging 7.8% (f=18)
Exciting 10.3% (f=3)		A science 8.5% (f=4)		Interesting 7.4% (f=17)
		Enjoyable 8.5% (f=4)		

'difficulty' in their images of mathematics. These results are disturbing and they are strikingly different from those given by their Malaysian counterparts. As displayed in Table 8.4, 17% of the Malaysian non-mathematics students viewed mathematics as enjoyable although 13% of them also noted 'difficulty' in their images of mathematics. Perhaps, this striking difference in images of mathematics might explain the markedly higher percentage of reported disliking of mathematics among the UK non-mathematics students as compared to the Malaysian non-mathematics students. However, these are the views of only a small part of the sample, and thus remain speculative.

Another interesting difference observed was that the image of mathematics as 'mental work' was prominently given by the Malaysian sample, but it was hardly mentioned by any of the subgroups of the UK teacher and student sample. Instead, some subgroups of the UK sample tended to relate mathematics to 'problem solving' and 'logical thinking' whereas these were not elicited in most of the subgroups of the Malaysian sample. Nevertheless, a word of caution here, the sample size is relatively too small to infer much from these results.

Despite these differences, there were some similarities in the images of mathematics given by these samples from both countries. First of all, both mathematics teachers and mathematics students from both countries prevalently viewed mathematics as enjoyable and interesting, much more than the non-mathematics teachers and students. Similarly, the mathematics teachers of both countries seem to view mathematics as a challenge more prominently than all the other subgroups. Likewise, the non-mathematics teachers of both countries shared a similar view of 'mathematics is difficult' (this was the most common response category given by both groups). In addition, images of mathematics as related to numbers and symbols were given by about 10% of the samples from both countries too.

(b) Images of learning mathematics

Unlike the images of mathematics, there were more differences than similarities in the images of learning mathematics given by the samples of both countries. For the Malaysian sample, images of learning mathematics were more commonly given in metaphoric forms. The two most common metaphors given by the Malaysian sample were:

(i) 'mathematics as a journey', such as learning mathematics is:

> like climbing up the mountain peak because you need to work hard, patient and persistence (M006, primary maths student, female, 17-20)

And (ii) 'mathematics as a daily life experience', where learning mathematics is like

> drawing a picture, must be careful and patient (M 120, primary non-maths student, female, 21-30)
>
> like fishing because you need confidence and patience (M036, primary maths students, male, 17-20).

These metaphors stress the need for continual work, and the importance of efforts, hard work and persistence in learning mathematics. As shown in Table 8.6, this image of 'learning mathematics as an effortful endeavour' was also the most common response category given by the Malaysian sample. In particular, this was most commonly perceived by the Malaysian mathematics students (17.8%) and non-mathematics students (9.0%). Other metaphors with similar implication given were:

> like eating durian - need to work hard to open it (M166, primary maths student, male, 21-30) [N.B. 'durian' is a Malaysian fruit with a thorny and hard shell)
>
> like a battery, without charging, it becomes weak, but with constant practise, learning it becomes enjoyable (M013, primary maths student, male, 21-30)
>
> learning about history, enjoying but exhausting (M405, secondary non-maths student, female, 17-20)

Perhaps these metaphors suggest that these students, who included the non-mathematics students, tended to stress the importance of effort and eventually they may work hard towards it.

On the other hand, although both the Malaysian mathematics teachers and non-mathematics teachers noted 'difficulty' in their images of learning mathematics, the former seemed to perceive it as a process that is 'difficult but rewarding'. For example, the Malaysian mathematics teachers perceived learning mathematics as,

> mountain climbing - the journey is difficult but reach the top at the end (M224, primary maths teacher, female, 31-50)
>
> a challenge that need to be faced with, satisfying when successful (M236, primary maths teacher, female, 31-50)

Table 8.6: Images of learning mathematics: list of the most common response categories

These images of learning mathematics suggest that the Malaysian mathematics teachers also found mathematics difficult but they took it as a challenge and something they must work towards that will bring success eventually. Interestingly, these views were shared by over 5% of the Malaysian mathematics and non-mathematics students too.

In contrast, images of learning mathematics given by the UK teachers and students were more varied and diverse. There was no common image of learning mathematics that was shared by all the four subgroups as compared to the Malaysian sample. Table 8.7 lists the most common subcategories of the images of learning mathematics of the UK teachers and students sample. The results show that learning mathematics was equated to 'problem solving', learning a 'skill' or 'games or puzzles' by nearly 5% of the UK teacher and student sample.

Table 8.7: Images of learning mathematics of the UK sample: list of the most common response categories

Similar to the images of mathematics, one noticeable difference between the two countries was observed in the images of learning mathematics given by the non-mathematics students. The Malaysian non-mathematics students viewed learning mathematics as an effortful endeavour, that involves the brain, is mind stretching and enjoyable, while the UK non-mathematics students related learning mathematics to frustration, difficulty, boredom and confusion. However, on the whole, only a minority expressed these views.

Some typical examples of images of learning mathematics given by the Malaysian non-mathematics students are:

> doing a job that need intense observation and hard work (M093, primary non-maths student, male, 21-30) or

> like fishing, need to know the materials, formula, patience and hard work to achieve success (M154, primary non-maths student, female, 21-30)

On the other hand, a typical example of images of learning mathematics given by an UK non-mathematics student is:

> banging my head against a brick wall (R054, non-math student, female, 21-30)

Interestingly, the same simile was also given by six other UK non-mathematics students.

These examples indicate the difference in emphasis from both samples. The UK sample more commonly displayed a relative intense negative feeling whereas the Malaysian sample often placed more stress on the importance of effort, patience and hard work. Although striking, these only represent minority views.

In comparing the mathematics teachers from both countries, it is interesting to observe that they shared a rather similar image of learning mathematics. One of the Malaysian mathematics teachers gave his image of learning mathematics as,

> like fishing - once you have a catch, you want to do it again and again (M228, primary maths teacher, male, 31-50)

This view of learning mathematics as related to something difficult but rewarding was also shared by one of the UK mathematics teacher:

> like climbing the mountain - worth the view (R292, maths teacher, female, 31-50)

Likewise, many non-mathematics teachers from both countries perceived the learning of mathematics negatively. While the Malaysian non-mathematics teachers tended to view learning mathematics as,

> trying to change something that is difficult, need certain technique or methods (M253, primary non-maths teacher, male, 31-50)

> cracking your head, watching your brain melting down (M356, primary non-maths teacher, male, 31-50)

The UK non-mathematics teacher viewed learning mathematics as:

> walking through mud (R155, non-maths teacher, female, 31-50)

Again, all these metaphors indicated negative feelings of 'difficulty' and 'struggling'. While over 10% of the Malaysian non-mathematics teachers still viewed learning mathematics as enjoyable, only two UK non-mathematics teachers (5%) shared this positive feeling. In addition, another difference between these two subgroups was that the UK sample held a problem solving view while the Malaysians a more symbolic view of learning mathematics. Nevertheless, the sample size is too small to infer too much from these results.

IV. Espoused beliefs about mathematical ability and gender differences in mathematical ability

Although the majority of both samples of teachers and students (UK - 92.2% and Malaysian - 95.3%) agreed that some people are better in mathematics than others, there were some striking differences in their responses as to which gender is better in mathematics, and the ranking of attribution factors for this mathematical ability.

(a) Beliefs about gender differences in mathematical ability

Table 8.8 displays a comparison between the two countries on their beliefs about gender

Table 8.8: A comparison between Malaysian and UK teachers and students on their beliefs about gender differences in mathematical ability

differences in mathematical ability. For the Malaysian sample, while the majority of the teachers (over 58%) believed that men are better in mathematics than women, less than 40% of the student sample believed so. Conversely, about half of the Malaysian students believed that both genderes are equally good at mathematics, but less than 38% of the teacher sample shared this same belief. These results suggest that better opportunities in education for the younger generation of Malaysians might have contributed to this shift of beliefs about mathematical ability. Or that there has been a shift of opinion. Nevertheless, there were still more than one third of the Malaysian students espoused that men are better in mathematics than women.

In contrast, for the UK sample, the majority of all subgroups believed that both genderes are equally good at mathematics. However, there were 14% less of the students than the teachers sharing this view. Instead, 10% more of the students as compared to the teachers believed that men are better in mathematics. But then teachers are better educated in general, and on these issues in particular, than the students.

Thus, the major difference between the two countries is that 80% of the UK teachers and students believed that there is no gender difference in mathematical ability while only half of the Malaysian counterparts shared this view. These results suggest that perhaps, equal and better opportunities in education for the new generations might have contributed to this shift in beliefs about gender differences in mathematical ability. Nevertheless, this remains a speculation without further research evidence.

(b) Ranking of attribution factors for differences in mathematical ability

For the respondents who agreed that some people are better in mathematics than others, they were asked to rank the list of four attribution factors: inherited mathematical ability, effort or perseverance, effect of mathematics teachers, and effect of home environment; from the most important to the least. So as to be consistent with the discussion in Chapter 5 Section IV.1, I used only the most important factor identified by the respondents, to indicate their attributions of mathematical ability.

While I was analysing the data, I encountered a problem in trying to make the data from the two samples comparable. First of all, the Malaysian sample suffered from the three problems that I had with the UK sample (as discussed in Chapter 5 Section IV.1). Secondly, in the Malaysian sample, about 20% did not rank the factors in order. Thus, instead of ranking all four factors in the order of '1-2-3-4', 14 of them ranked all of them as the most important '1-1-1-1' while others ranked these factors as '1-1-2-2' or '2-3-2-4' or '1-1-2-3' and so on. I interpreted these responses to mean that some of the Malaysian respondents were uncertain in the ranking or they considered some factors were equally important. However, in order to have the two samples from both countries comparable, I decided to select only cases (or respondents) that ranked all four factors in the order of 1-2-3-4. As a result, the reduced sample size for the Malaysian teachers and students was 255 while that of the UK teachers and students was 131. Consequently, the percentage was calculated based on the reduced sample size. Figure 8.1 displays a comparison of the rankings of contributing factors selected by the samples from the two countries based on these percentages.

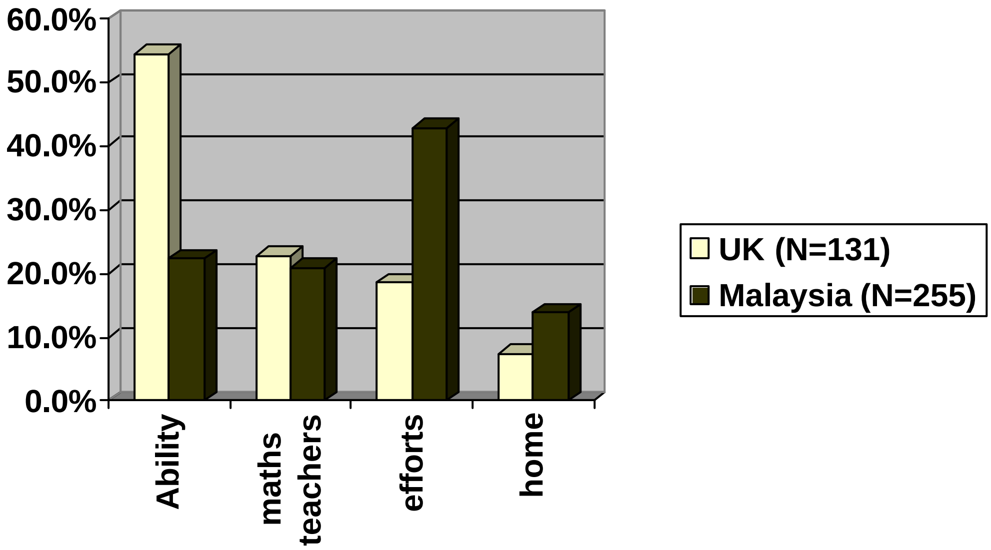


Figure 8.1: A comparison between the UK and Malaysian teachers and students on the ranking of attributing factors for differences in mathematical abilities (Based on the most important factor or first choice)

Figure 8.1 shows that 'inherited mathematical ability' was ranked as the most important contributing factor (54.5%) by the UK teachers and students. However, this factor was ranked as the second most important attribute by the Malaysian teachers and students. Instead, 43% of the Malaysian teachers and students ranked the factor 'effort and perseverance' as the most important contributing factor. This finding is interesting because it indicates there is a cultural difference in the attribution of causal factors for a person's mathematical ability. Indeed, this finding concurs with several cross-cultural studies (Ryckman and Mizokawa, 1988; Huang and Waxman, 1997), that Eastern families tend to value effort, perseverance and hard work while Western families tend to rely on mathematical ability and creativity as important contributing factors for success in mathematics. Nevertheless, inherited mathematical ability is still considered as one of the important factors by the Malaysian sample because 22% of them chose it as the most important factor. This percentage indicates that one fifth of the Malaysian teachers and students believed that difference in one's mathematical ability is possibly linked to one's inherited mathematical ability.

Besides effort and mathematical ability, the mathematics teacher factor was ranked as the next factor of importance by the teachers and students from both countries. In fact, the percentage given by the Malaysian teachers and students was only 2% less than that of the UK teachers and students. These results indicate that both samples recognised the important role of mathematics teachers in a person's success in mathematics.

In addition, another noteworthy difference between the two countries was the attribution of importance to the 'home environment'. While 19.4% of the Malaysian teachers and students sample attributed a person's success in mathematics to home environment, only 7.4% of their UK counterparts did so. Perhaps this is not a surprise because this is another cultural difference that has been observed in some cross-cultural studies (see e.g., Huang and Waxman, 1997). The results of these studies show that the Asian parents were more likely to have more interest and paid more attention to their children's work in mathematics learning than their Western counterparts in the study.

In summary, the overall results show that there are cultural differences in the ranking of attributive factors in determining the differences in mathematical ability. The majority of the Malaysian teachers and students ranked effort as the major factor of importance while their UK counterparts ranked inherited mathematical ability. However, the mathematics teacher factor was ranked as the next factor of importance by almost equal percentage of both samples from both countries.

V. Views about the importance of school mathematics

As in section IV above, I encountered similar problems when analysing the data in ranking the reasons for the importance of school mathematics. So as to be consistent with the above analysis, I used the score of the most important reason identified by the respondents, to indicate their views about the importance of school mathematics. I applied the same treatment to the data as in section IV above, and obtained a reduced sample size of 191 and 384 for the UK and Malaysian teacher and student samples respectively. Figure 8.2 displays the comparison between the two countries.

The majority of the teachers and students from both countries (the UK sample- 96.1% and Malaysian sample - 99.8%) shared the same view that school mathematics is very important. They also ranked in similar manner the major reason for the importance of school mathematics as 'it is useful for everyday life' followed by the reason 'it helps industry and commerce'. These results suggest that both the UK and Malaysian sample in this study emphasise the utilitarian aspect of school mathematics.

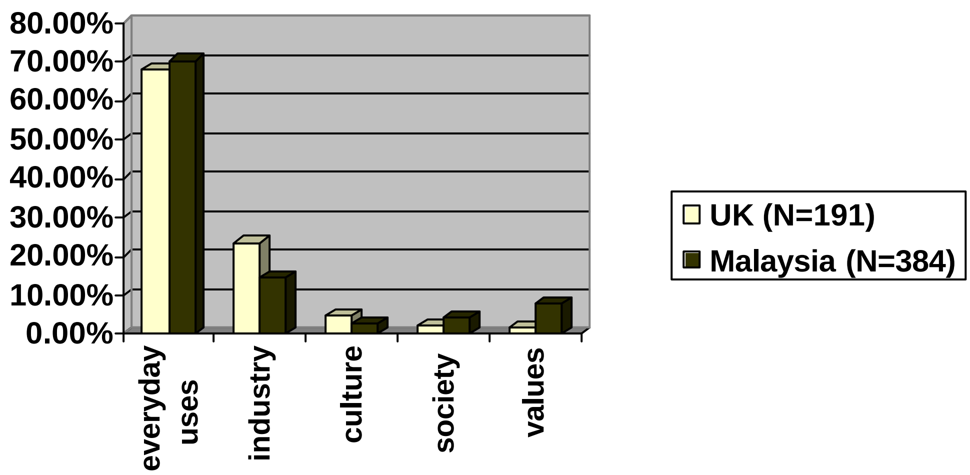


Figure 8.2: A comparison between the UK and Malaysian sample on the ranking of the importance of school mathematics

However, there was one interesting difference observed between the two countries in their ranking of the statement, 'It teaches moral values'. While 7.8% of the Malaysian teachers and students ranked this as the most important reason for the importance of school mathematics, only 1.6% of their UK counterparts shared the same view. This reflects another cultural difference in the emphasis of the importance of school mathematics. Lim and Ernest (1997) report how 16 moral values have been explicitly spelled out in the Malaysian curriculum, including in mathematics. The explicit attention to and integration of these values into mathematics teaching and learning are likely to have impact on the sample's view about the importance of school mathematics. Perhaps, this impact is reflected in the results. However the sample size of this study was again too small and not generalisable to allow any conclusive remark to be made here.

VI. Belief about the nature of mathematics

The sample was given six statements of belief about the nature of mathematics to choose from. Table 8.9 displays a comparison of the analysis of these beliefs of teachers and students from both countries. The results show that there were striking differences in their beliefs about the nature of mathematics between the samples from the two countries in at least five out of the six statements given. However, within subgroups of each country, for only two statements were marked difference found for the UK sample and only for one statement for the Malaysian sample. These results suggest that on the whole, the beliefs about the nature of mathematics were rather consistent or similar among the subgroups of each country.

Table 8.9 shows that 79% of the Malaysian teachers and students believed that mathematics is exact and certain but only 54% of their UK counterparts shared the same belief. Similarly, only 49% of the Malaysian sample considered puzzles and games are proper mathematics as compared to 80% of the UK sample. These results suggest that the Malaysian sample tended to hold an absolutist view about mathematics while the UK sample more of the fallibilist view about mathematics (see Ernest, 1991).

According to Ernest (1991), an absolutist view of mathematics is characterised by mathematics consisting of a set of absolute and unquestionable truth. In addition, mathematical truth is exact and certain, while mathematical knowledge is objective, value-free and culture-free. In contrast, the fallibilist view of mathematics is characterised by "mathematical truth is fallible and corrigible, and can never be regarded as beyond revision and correction" (Ernest, 1991, p.18).

However, the majority of both samples seem to share the same view that a mathematical problem can be solved in different ways. Surprisingly, more than 65% of the UK sample believed that mathematics is a collection of rules and procedures while only 27% of the Malaysian sample believed so. These results seem to contradict the earlier

Table 8.9: A comparison between Malaysian (UK) teachers and students on their beliefs about the nature of mathematics

VII. Images of mathematicians and their work.

How people view mathematicians and the way they carry out their works in mathematics will indirectly reflect their images of mathematics. So, the sample was also asked to choose the characteristics of a typical mathematician and their possible ways of carrying out their works. Although in practice, it would not make sense to talk about a typical mathematician, however, this exercise was designed to tap into the samples' preconceptions and stereotypes. The results of the comparison between the two countries are displayed in Table 8.10 (for the characteristics of a mathematician) and 8.11 (for images of a mathematician's work).

(a) Characteristics of a mathematician

More than three quarters of the Malaysian sample agreed that two of the important characteristics of mathematicians are that they are 'confident' and 'intelligent'. Likewise, more than half of them thought that a mathematician is possibly 'serious', 'strict', 'male' and 'wear glasses'. Interestingly, among the Malaysian subgroups, there was no striking difference in any of the characteristics chosen, except 'odd/funny' and 'female'. These results suggest that on the whole the Malaysian teachers and students have quite a coherent picture of a mathematician as somebody who is strict, serious, confident and intelligent. However, there were 10-15% more of the Malaysian students than the teachers who viewed a mathematician to be 'funny or odd' and possibly 'female'. This latter result also support the earlier result on gender difference in mathematical ability (see this chapter Section IV(a)) that more Malaysian students than teachers believed that both gender are equally good at mathematics, albeit the percentage was still reasonably small (only 20-26%).

On the other hand, for the UK sample, as in the earlier section, the images of a mathematician among the different subgroups were more varied than their Malaysian counterparts. There were marked observed differences among the four subgroups on the characteristic of 'confident', 'intelligent', 'wear glasses', and 'bald'. For the first two characteristics, the mathematics teachers were the most in believing so while for the latter two, they were the least. This result indicates that the UK mathematics teachers tended to have a relatively different image of mathematicians as compared to the other subgroups.

Table 8.10: A comparison between Malaysian (UK) teachers and students on the characteristics of a mathematician

	Malaysian teacher and student (UK teachers and students)
	25.8% (4.3%)

In a comparison between the samples from the two countries, there were far less of the UK teachers and students having the image of a mathematician as 'confident', serious', 'strict', 'male' and 'wearing glasses', as compared to what was viewed as typical by the Malaysian teachers and students. As shown in Table 8.10, less than one third of the UK sample indicated these features as the characteristics of a mathematician. However, 56% of the UK teachers and students believed that a mathematician is 'intelligent'. These results suggest that the samples from the two countries hold relatively different images of a mathematician, presumable reflecting differences in their experiences and media portrayals of mathematics in the two countries.

(b) Images about a mathematician's work

Table 8.11 shows that among the Malaysian sample, there were no major difference between teachers' and students' images about how a mathematician carries out his/her work. More than 70% of them agreed that a mathematician engages in 'carrying out complicated calculations', 'testing examples with formulae', 'discovering, creating and inventing new formula or mathematical ideas'. However, only 30% of them believed that a mathematician carries out his/her work by 'guessing mathematical rules' or 'trying to prove other people's formula is wrong'. These results suggest that the Malaysian sample tended to view a mathematician's work as more related to an absolutist view of knowledge than a fallibilist view. Absolutists regard mathematics as comprising 'fixed' or 'proper' methods such as carrying out complicated calculations, testing and formulation. Whereas fallibilists believe that there are multiple methods of solving mathematical problems, including the use of guessing and falsification.

In addition, about 50% of the Malaysian teachers and students agreed with two statements: 'using their intuitions' and 'solving real world problems'. However, 40% of them indicated they were 'unsure' on these two statements. These findings seem to support my earlier speculation that the Malaysian sample tend to hold an absolutist view of mathematical knowledge and they believe that methods such as the use of 'intuition', guessing and falsifying are not proper methods to be used by mathematicians.

In contrast, the UK teachers and students held varied views about how mathematicians work. In particular, the UK mathematics teachers seemed to hold a prominently fallibilist view of a mathematician's work as compared to the other subgroups. More than 72% of them agreed that a mathematician's work include 'guessing mathematical rules' and 93% of them agreed that mathematicians use falsifying method, such as to falsify existing mathematical theories or formula, in their works. These results suggest

Table 8.11: A comparison between Malaysian (UK) teachers and students on images of how mathematicians find new knowledge

Nine suggested ways	Malaysian teacher and student groupings (UK sample)				
	Maths teachers n=36 (n=29)	Other teachers (non-maths) n=64 (n=38)	Maths students n=174 (n=47)	Other students (non-maths) n=133 (n=117)	Total N= 407 (N=231)
Carrying out complicated calculations	60.0% (58.6%)	64.1% (63.2%)	75.9% (48.9%)	71.2% (68.4%)	71.1% (61.9%)
Guessing mathematical rules	40.0% (72.4%)	29.7% (39.5%)	28.9% (23.4%)	28.8% (31.6%)	30.0% (36.8%)
Testing examples with formulae	91.4% (75.9%)	90.6% (86.8%)	94.8% (76.6%)	90.2% (83.8%)	92.3% (81.8%)
Trying to prove other people's formula is wrong	31.4% (93.1%)	17.2% (47.4%)	27.6% (70.2%)	22.7% (59.0%)	24.7% (63.6%)
Using their intuitions	62.9% (86.2%)	54.7% (73.7%)	48.9% (59.6%)	52.3% (61.5%)	52.1% (66.1%)
Solving real world problems	54.3% (79.3%)	53.1% (76.3%)	43.1% (68.1%)	50.0% (47.9%)	47.9% (60.5%
Discovering new formulae	77.1% (72.4%)	78.1% (71.1%)	83.3% (59.6%)	81.1% (75.2%)	81.2% (70.6%)
Creating new formula and rules	80.0% (79.3%)	73.6% (68.4%)	71.9% (55.3%)	76.5% (77.8%)	74.8% (71.5%)
Inventing new mathematical ideas	77.1% (75.9%)	81.3% (59.6%)	77.6% (60.5%)	77.3% (67.5%)	78.0% (65.4%)

Note: Figures in parentheses indicate results from the UK samples

In comparison, only 40% or less of the UK non-mathematics teachers and both groups of students believed that "guessing mathematical rules" is one of the ways that a mathematician works. In addition, there was far less from these subgroups (about 23% to 40%) agreed that mathematicians use falsification. Similarly, the percentages of the UK students agreed that mathematicians use 'intuitions' in their work were 25% less than that given by the mathematics teachers. These results suggest that the UK non-mathematics teachers and students in this study were more likely to hold an absolutist view rather than a fallibilist view of mathematical knowledge, which was held more often by the mathematics teachers.

Interestingly, there is a similarity exhibited by both samples from the two countries. Almost equal percentages of the four subgroups from both countries agreed that mathematicians 'discover, create and invent new mathematical formula or ideas'.

In short, these results suggest that the samples from both countries shared relatively similar views about a mathematician's work. Even though the Malaysian teachers and students were more inclined toward an absolutist view, the UK sample, in particular the mathematics teachers tended to hold a more fallibilist view of mathematical knowledge and knowledge creation.

8.6 Discussions

As I have suggested in chapter 3, images are assumed to be formed as a result of personal experiences, influenced by significant others such as parents, teachers, as well as culture and society. Similarly, images of mathematics were apparently found (discussed in chapter 6 and 7) to be most commonly influenced by an individual’s mathematics learning experiences in school, as well as by their mathematics teachers and parents. In addition, society at large, including cultural values and the mass media probably also influences the formation of a person's images of mathematics. A comparison between the UK and Malaysian teachers' and students' images of mathematics thus provides us with an insight into the possible influence of cultural values on images of mathematics. In view of cultural differences between the two countries, the findings might serve to support or challenge the recent propositions that images of mathematics are culture-bound and value-laden as proposed in some literature (see example, Bishop, 1988; Ernest, 1991).

The findings of this cross-cultural study show that overall, there were more differences than similarities in images of mathematics among the teachers and students between the two countries. Some striking differences were found in terms of reported liking (disliking), images of mathematics and learning mathematics; beliefs about gender differences in mathematical ability, beliefs about attribution factors to mathematical ability, and images of mathematicians and their works.

First of all, the Malaysian teachers and students displayed relatively more positive attitudes towards mathematics than the UK teachers and students. They not only showed higher percentages in reported liking and relatively lower percentages in reported dislike of mathematics (only 5.7%), they also reported more positive feelings towards learning mathematics in schools. In particular, the Malaysian non-mathematics students displayed noticeably higher percentage of reported liking than their UK counterparts (69% instead of 37%).

Secondly, in terms of images of mathematics, the Malaysian sample commonly viewed mathematics as a subject that was enjoyable and challenging, albeit difficult for some people. Learning mathematics was more often characterised as an activity that was an effortful endeavour and required mental activity. In contrast, the UK sample viewed mathematics more frequently in terms of boredom and difficulty. Commonly, they reported negative feelings such as 'boredom' when they thought of learning mathematics in school. This is particularly notable in the UK non-mathematics student sample.

Thirdly, the results suggest that there is a cultural difference in the factors to which a person’s mathematical ability is attributed. While the majority of the Malaysian sample attributed 'effort and perseverance' as the most important factor, the majority of the UK sample ranked 'inherited mathematical ability' as the most important factor. This finding concurs with that of many cross-cultural studies ((Ryckman and Mizokawa, 1988; Stevenson & Stigler, 1992; Huang and Waxman, 1997) that Eastern families tend to value effort, perseverance and hard work whereas Western families tend to rely on mathematical ability and creativity as important contributing factors for success in mathematics.

On the other hand, this finding seems to challenge the findings of two recent studies (Gipps & Tunstall, 1998; Elliot, Hufton, Hildreth & Illushin, 1999), which observed that some English young children had quoted effort rather than ability as the major reason for success in mathematics (Gipps & Tunstall, 1998) and in school work (Elliot et al., 1999). Perhaps this is an optimistic notion and that there might have been a shift in belief about mathematical success in the younger English generation. However, samples in these studies, including those in this cross-cultural study, are by no mean representative of their countries, thus these findings remain inconclusive unless more consistent evidences are found.

Overall, these two findings seem to suggest that the images of mathematics and learning mathematics were closely linked to beliefs about mathematical ability. As the Malaysian sample believed that effort and perseverance were important factors for success in mathematics, they viewed learning mathematics as an effortful activity. They admitted that learning mathematics could be difficult but they perceived the difficulty as a challenge, not as an obstacle. This belief of ability as driven by effort and the image of mathematics as a challenge might promote a willingness to work harder. This sample might then have achieved a sense of satisfaction and enjoyment at their success. As a result, they might tend to display a more positive attitude towards mathematics and learning mathematics. This is a plausible chain of causal links, but without further confirmation, it remains a speculation.

In contrast, the UK sample attributed success in mathematics to 'inherited mathematical ability'. Consequently, they might not believe that working hard would help them to achieve better, especially if they might believe that they themselves lack mathematical ability. They might tend to believe that mathematical success was only possible for a few clever ones. They might tend to give up more easily and to see themselves as failures in mathematics. As a result, they might not accept difficulty in mathematics as a challenge. Instead, they might tend to adopt a negative attitude towards mathematics and easily feel bored and frustrated, even when they have experienced little failure in mathematics. Again, this is a plausible chain of causal links, but without further confirmation, it remains a speculation.

Lastly, while the Malaysian teachers and students tended to adopt an absolutist view of mathematical knowledge, the UK teachers and students tended to subscribe to a more fallibilist view. For the majority of the Malaysian teachers and students, mathematical knowledge was exact and certain. There was always a right answer to any mathematical problem, even though some of them believed that there were more than one way to solve a mathematical problem. They also believed that mathematicians tended to use fixed and rigorous methods such as ‘testing’ and ‘complicated calculation’, and formulation. Methods such as 'guessing', 'intuition' and 'falsification' were considered as 'improper' methods.

In contrast, the UK teachers and students displayed a wider range of views about mathematical knowledge. The mathematics teachers tended to exhibit a relatively stronger inclination towards a fallibilist view of mathematical knowledge whereas the students and the non-mathematics teachers exhibited a mixture of absolutist and fallibilist view of mathematical knowledge.

8.7 Conclusion

While it should be recognised that the two samples studied are by no mean representative of the two countries, the findings do serve to highlight the possible influence of culture and values in the formation of images of mathematics among some teachers and students of both countries.

The comparison made in this cross-cultural study between the two countries both supports and challenges any notion that image of mathematics is value-laden and culture-bound. By and large, cultural differences in beliefs about mathematical ability and the importance of mathematics education might have resulted in different emphases in the process of learning mathematics in school. As a result, differences in mathematics learning experiences might have brought out differences in people’s images of mathematics and learning mathematics. Consequently, this might conceivably have given rise to the differences in attitudes towards mathematics and learning mathematics as well.

On the other hand, it might be argued that the differences could be due to the different influences of significant others in the two countries (such as mathematics teachers and parents), or the different cultural presuppositions. As Elliot, Hufton, Hildreth & Illushin, (1999) point out that "perhaps more important are children's familial, peer and cultural perceptions about what constitutes real and meaningful educational achievement and the extent to which this is seen to be of such intrinsic or extrinsic values as to evoke significant effort" (p.91). Thus, I acknowledge that due to the limits of inferences that can legitimately be drawn from a questionnaire survey, these claims remain speculative and need to be confirmed by further research studies on these matters.

Finally, most cross-cultural studies of the last 30 years have focused on comparing mathematics performance of students between Western industrialised countries such as USA, Eastern Europe and UK, and Asian countries such as Japan, China, Taiwan and Korea (e.g., Husen, 1967; Song & Ginsburg, 1987; Stigler & Perry, 1988; Robitaille & Garden, 1989; Stevenson & Lee, 1990; Stevenson & Stigler, 1992; Cai, 1995; Beaton et al., 1996; Reynolds & Farrell, 1996; Keys et al.,1997). More recently, there is also an increasing number of research studies on cultural beliefs and values, as well as on social and parental expectations that seek to explain these differences in mathematics performance and motivation in learning mathematics (e.g. Stevenson, Chen, & Uttal, 1990; Samimy et al., 1994; Eaton & Dembo, 1997; Gipps & Tunstall, 1998; Elliot et al., 1999). However, as yet there are no cross-cultural studies comparing UK and Malaysian samples involving images of mathematics. Moreover, most of the above mentioned studies have sampled elementary and high school students, and relatively few college or university students. Therefore, results of this cross-cultural study, albeit limited and not generalisable, may serve to at least temporarily fill in these gaps and knowledge, and thus provide a glimpse of possible cultural differences in the images of mathematics as displayed by the students and teachers in the two countries.

Chapter 9

Conclusion

In this chapter, I first spell out the limitations of the study before offer my conclusions of the findings of this study. I then draw out some suggestions for future research, based on the limitations and weaknesses that I have learnt from this study. Finally, I conclude the chapter with my personal reflections on this overall research project.

9.1 Limitations of the study

I acknowledge that there are a number of limitations in this study due to the nature of the sample, methods of data collection and analysis, as well as the researcher's personal values and preferences.

First of all, the sample of the study was an opportunity sample, whereby only those who volunteered to participate were included. In spite of my efforts to partially stratify the sample by age and by occupational groupings, as well as to include as far as possible all the categories of the British public adult members (indicated in Chapter 4), certain sections of the public are inevitably under-represented while the others were over-represented. In addition, sampling was restricted to one provincial city (Exeter) plus a smaller number of tourists and university students from the other parts of UK. The lack of geographically distributed sampling, necessitated by the restricted resources available to the researcher, also limit the representativeness of the sample. Therefore, the overall findings of this study are limited in representativeness and generalisability. However, as I have argued earlier, the main aim of this study is not to generalise or to find a typical image of mathematics that is representative of the UK public, although findings on the public attitudes to mathematics of even this limited sample is of great interest. In fact, my main interest is to explore the possible range of the public images of mathematics, and to gain a better understanding of the possible influences and causes of these images. Some progress, albeit limited, has been made towards these goals.

Secondly, in the small scale cross-cultural element, this study only compares the images of mathematics of the students and teachers of both UK and Malaysia. The sampling of the Malaysian data was restricted to the two teacher-training colleges described in Chapter 8 (Section 8.4). Thus, the results on cross-cultural comparison of this study are limited to these groups of teachers and students from these two countries only. These findings are not generalisable to the full populations of teachers and students from both countries.

Thirdly, the use of telephone interviews as a method of data collection in this study necessarily resulted in the lack of personal contact (such as facial expression and body language) between the respondent and the researcher. Consequently, as noted by Groves and Kahn (1979) that this may lead to a faster pace of response during the telephone interview and resulted in shorter answers being given as well as less clues as to the respondent's meanings. Thus, the quality of the answers and the completeness of the responses may be less satisfactory. However, I attempted to resolve this problem during the interviews by careful prompting and listening, and allowing sufficient waiting time for the respondent to think and respond. Nevertheless, the interview data collected in this way is still limited to only verbal expressions of the respondents. I acknowledge that it is not possible for me to incorporate the respondent's other physical expressions or body language into my interpretation of the interview data. However, such supplementary information should be less important than respondent's explicit linguistic responses.

Fourthly, I used some open-ended questions to explore people's images of mathematics in the questionnaire. As mentioned in Chapter 4, the provision of examples may have suggested certain types of answers, although the actual answers given were not influenced by the examples. Moreover, this method requires textual responses, which are open to multiple interpretations, and lead to the possibility of the interpretation of these responses outside the social context and the personal meanings of the respondents. In addition, it is unavoidable that I will bring in my own personal values and preferences during the interpretation of the data. However, I have employed various techniques such as cross-validation or investigator triangulation (Smith, 1975) and triangulation of methods (Denzin, 1970) to minimise the distorting influence of my own personal bias and preferences. I also acknowledge these limitations in reporting and discussing the results of the study, as to some extent they cannot be eliminated altogether.

Fifthly, I used a closed questionnaire to probe into people's liking or disliking of mathematics, their attitudes to and beliefs about mathematics. There are some weaknesses in using a closed questionnaire. As the questions were constructed with fixed responses, this may limit the type of possible response from the respondents. In addition, there might be ambiguity in some of the terms used in the questions (e.g. the term, 'mathematics') and this might possibly open to multiple interpretations from the respondents. Thus, I acknowledge that this is another limitation of the study and I have also noted the possible ambiguity and interpretation of the different terms in my discussion of the definition of some specific terms (see Chapter 3, Section 3. 4), as well as in the discussion of the findings. It was necessary to balance the thoroughness and depth of the questionnaire with a form public passers by would find time to respond, and this area of limitation is one of the outcome of this 'trade-off'.

Sixthly, being a non-native speaker, I acknowledge that I have problems in transcribing the interview data, which are collected entirely from British respondents. These problems include misinterpreting some spoken words and the meaning of some words spoken by interviewees in local slang, and further possible misunderstandings arising from my unfamiliarity with the local culture and language. I have attempted to validate my queries and settle any uncertainties with regard to the meaning of terms (and cultural-related language) as far as I can with the assistance of either the interviewees, my supervisor or my British friends, to best ensure that I understood the message conveyed by them. However, I acknowledge that my unfamiliarity with certain words or language used in the British context might add to the limitations of this study. Since the transcripts of interviews were not validated with the respondents after the interviews, some uncertainties with regard to transcription and interpretation must inevitably remain.

Seventhly, during the interviews, I tried to allow my respondents to elicit their feelings and recall their experiences of learning mathematics. However, at times I had to prompt them with some key terms, and asked questions such as 'do you think your mathematics teacher might have influenced you…?' I acknowledge that this kind of explicit prompting might draw the attention of my interviewees to these issues. As a result, I might have introduced the so-called 'interviewer bias' (Cohen and Manion, 1994) whereby the respondents might have responded differently from the way if they themselves brought out these issues. On the other hand, I argue that making these questions explicit might help to ensure that each interviewee were asked consistently on the same kind of questions. Furthermore, for many of these prompts the interviewees rejected the possible link and causal factors. I also acknowledge that there remain some differences in my interview approach between the first and the last interviews. This is because as I became more experienced in interviewing, inevitably my interviewing technique improved. Thus, the use of semi-structured interview and a list of prompts had the effect of partly compensating for this by helping me to ask questions consistently to my respondents.

Eighthly, I acknowledge that using open-ended questions to explore people's images of mathematics will allow the respondents to express themselves more freely and creatively in their responses. Thus, it is possible that some people might just make up a response 'off the cuff' or to please the researcher. There is thus the possibility that the question asked might trigger the respondent to reflect and construct their image on the spot. Having said that, the analysis of the data shows that 36 (80) respondents did not respond to the open-ended questions on image of mathematics (image of learning mathematics, respectively). This shows that some respondents were not moved to report or 'make up' an image. In addition, for a subsample (chosen for follow-up interviews), there was consistency between the images given in the questionnaire and the interview data, as well as in their descriptions about their experience of learning mathematics in school. This consistency suggests that these images were long-lived and persistent, and were not made up on the spot. Nevertheless, I acknowledge that there remains a possibility that some respondents might exhibit researcher-desired behaviour or respondent bias (Cohen and Manion, 1994) as with any qualitative method of enquiry. Any inquiry into attitudes or beliefs must face the possibility that it is not tapping into 'real' permanent dispositions and conceptions.

Lastly, due to the weakness of using what is essentially an opportunity sample, I acknowledge that there is a possibility that some respondents might volunteer to respond to my questionnaire out of obligation. 35 % of my data was collected in and around the university campus (where I am a student) and 20% of the data was collected through my friends and colleagues. Thus, I acknowledge that some of them might have the tendency to answer the questionnaire in a way to please me. As a result of these possible respondents bias (Cohen & Manion, 1994), to some extent, some of these data might not reflect the real situation. However, I have carried out a further analysis on this issue. I have divided the sample into two main groups: (a) respondents from university and through friends, and (b) respondents that I met on high street, bus station and other locations. I compared the distribution of reported liking among different age and occupational groupings. I found similar pattern of distribution of reported liking of mathematics among the different subgroups between these two main groups. These results suggest that difference in location and source of data collection may possibly have some effect on the overall results of the study, but the effect is relatively negligible, as the sample size of the study is relatively large.

Clearly these are substantial limitations to this study, and the above list may well not be exhaustive. However, I believe there is much to be learnt from this study both in the realms of improved methods and future studies (see Section 9.3) as well as the actual findings of the study.

9.2 Conclusion

Acknowledging the above limitations and in particular the problem of the representativeness and generalisability of the data, I would argue again that this study was not carried out to provide widely generalisable empirical data or evidence. Rather, I hope that by looking into adults' images of mathematics, the findings might provide us with a better insight and understanding, albeit preliminary, into adults' mathematics learning or at least some of its outcomes. Subsequently this information might serve as a source of further research studies on the area for mathematics education researchers, besides providing useful suggestions to others on mathematics education or those concern with the public image of mathematics and science.

On the whole, findings of this study show that adult's images of mathematics are unique and personal, and utilise a wide variety of verbal representations, descriptions and metaphors. Most people in this study seem to hold more than one of the five main views that recurred among the sample. These most common views include (i) utilitarian views, (ii) symbolic views, (iii) absolutist or dualistic views, (iv) problem solving views, and (v) enigmatic views. Among these, the majority of the sample held a utilitarian view or a symbolic view. In addition, these two views are more commonly held by those who claimed to dislike mathematics than those who claimed to like mathematics. For the latter, more seem to hold an enigmatic view or a problem solving view of mathematics. Albeit inconclusive, there appears to have been some links between views of mathematics and reported liking (or disliking) of mathematics among the sample.

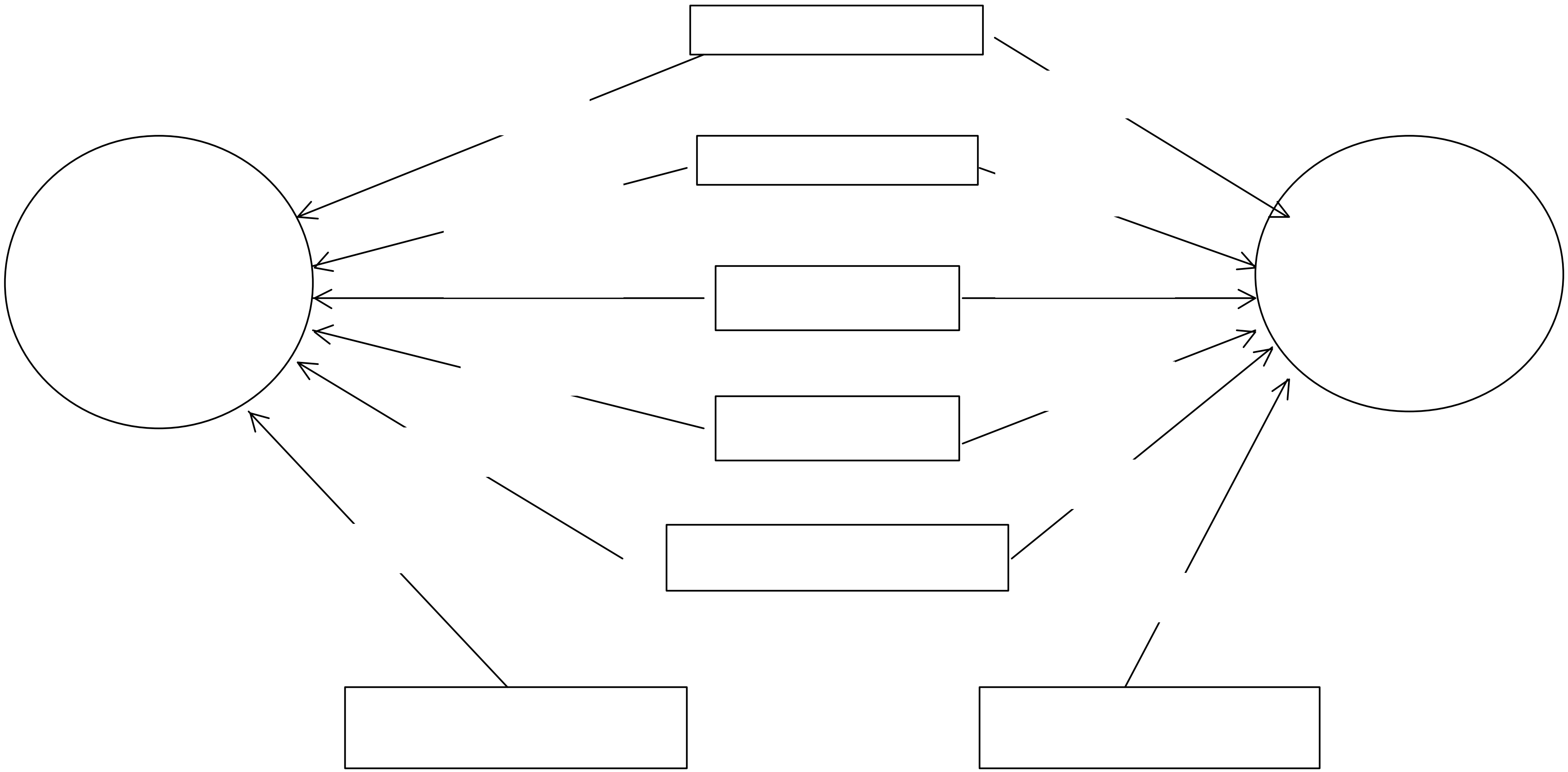
Perhaps this link is not a surprise because viewing mathematics in terms of its utilitarian values (i.e. a utilitarian view), and as a system of symbols and numbers (i.e. a symbolic view) might not of itself sustain a person's interest in mathematics. As these views are primarily external and superficial, they are consistent with a lack of involvement or personal 'ownership' of mathematics. Instead, perhaps it is only the people who learn to appreciate the beauty and mysterious nature of mathematics (i.e. holding an enigmatic view), as well as enjoying the satisfaction of solving problems in mathematics (i.e. holding a problem solving view) that may further their interest in mathematics, and indicate a personal relationship or sense of 'ownership' of the subject. Although these conclusions are purely speculative without further research evidence, they do suggest possible explanations, which further research could explore, illuminate and build on.

Albeit limited in representativeness, these findings with regards to the common views of mathematics seem to concur at least in part, with other research studies on mathematicians' views of mathematics (Mura, 1992; Grigutsch and Törner, 1998), and mathematics teachers' and student teachers' views of mathematics (Kelly & Oldham, 1992; Wilson, 1992). For example, Grigutsch and Törner (1998) found that the majority of their mathematician sample viewed mathematics as a process, which is characterised by "an activity of thinking about problems and achieving realisations" (p.16). This is a problem-solving view. Some also held something akin to the enigmatic view, seeing mathematics as an "aesthetic divine game" (p.24). Presumably, mathematicians are those who like mathematics and who have a positive image of mathematics. Thus, it is interesting that, albeit inconclusively, the findings of this study partly reflect this trend of positive image, which is likely to be closely linked to the problem-solving and enigmatic views of mathematics.

On the other hand, Kelly and Oldham (1992) observe that their samples of primary teachers and student teachers seem to hold absolutist and utilitarian views of mathematics and a 'more process-oriented' view of mathematics education. Likewise, in Wilson's (1992) study, the three prospective secondary mathematics teachers were inclined to the dualistic and symbolic views towards functions (as part of mathematics). Perhaps it is not surprising to observe these views (i.e. absolutist, utilitarian, symbolic and problem-solving) to be common among the sample of this study too. However, findings of this study seem to suggest that to many adult members of the UK public, particularly laymen on the street who have little involvement in mathematics or mathematics education, mathematics is more likely to be viewed for its utilitarian applications in daily life and work, and its symbolic notations. As a result, some of them are more likely to exhibit negative images of mathematics if they fail to see the relevance of mathematical applications in their daily life or their work. Worse still, if they fail to appreciate the abstractness and logical rigour of mathematical symbols and notations. This is a plausible link between images of mathematics and attitudes to mathematics, but it remains speculative without further confirmation by research evidence.

Most respondents in this study seem not to differentiate their images of mathematics from their images of learning mathematics. This suggests that there is possibly a close link between some respondents' images of mathematics and their experiences of learning mathematics in school in that they do not separate them strongly. This is plausible as images have been described as fragments of both past affective and cognitive experiences (Thompson, 1996a) or fragments of memory and reconstructions of experiences (Horowitz, 1978).

The results seem to show that the images of mathematics of the sample were related to or influenced by more than one single factor. The relationship between these various factors seem to be inter-related and intertwined. However, a comparison between those who claimed to like mathematics and those who claimed to dislike mathematics shows that there were noticeable differences in the characteristics of these influential factors (see detailed discussion in Chapter 7, Section 7.3). Here I summarise the results with the percentage of occurrence of the various factors among the interviewees and display them as a conjectural model of formative influence for the positive and negative images of mathematics in Figure 9.1. Those who claimed to like mathematics were the group most commonly exhibiting a positive image of mathematics while those who claimed to dislike mathematics exhibited the opposite.



In the interview sample, the influence of mathematics teachers was the most frequently noted by the respondents who reported a dislike of mathematics (58%), as well as those who reported a liking of mathematics (64%). For the former group, most of these respondents claimed that their mathematics teachers did not explain well, were sarcastic, did not have enough patience, or did not give them enough attention. In contrast, the mathematics teachers of those who reported a liking of mathematics were claimed to be inspiring and encouraging, explained the subject well, and gave attention and time to their students to the latter's satisfaction. Although limited in generalisability, these results lead to the tentative conclusion that mathematics teachers might be one of the major influences on the respondent's images of mathematics. Consequently, this also suggests the important role of mathematics teachers in a person's experiences of learning mathematics in school.

Perhaps this finding is not surprising in view of the wide acceptance of the significant role of teachers (particularly mathematics teachers) in mathematics learning (see Royal Society, 1976; Lerman, 1993). This role can be enacted in a variety of ways. Thus, mathematics teachers' images of mathematics (Brown, 1992), as well as teachers' attributions about student's success or failure in mathematics (Fennema et al., 1990) were found to have an impact on students' learning of mathematics. In addition, McSheffrey (1992) found that mathematics teachers were one of the major focuses of his women sample's reasons for avoidance of mathematics. More generally, the full range of teachers' interactions with pupils may affect pupils' attitudes to the subject matter.

However, a word of caution is needed here. In this study, the notions of 'good' or 'bad' mathematics teachers are relative and personal to the respondents. Nevertheless, there are some similarities and consistency in the samples' account about their experiences of mathematics teachers and their learning of mathematics in school. Thus, overall I would argue that, albeit limited, the findings of this study suggest that mathematics teachers have a major influence on the images of mathematics of the subjects of this study, and possibly more generally.

In addition to mathematics teachers and mathematics learning experiences in school, parents, cultural beliefs and values seem to also exert some influence on people's images of mathematics. Notably, the cross-cultural comparison between samples of teachers and students of Malaysia and a comparable UK subsample indicated that there were striking variations in these sample's images of mathematics and their beliefs about attributions for success in mathematics, across the two countries. The Malaysian teachers and students regarded effort and perseverance as the most important factors for success in mathematics and they tended to view learning mathematics as an effortful endeavour and to perceive difficulty in mathematics as a challenge, and not an obstacle. On the other hand, the UK teachers and students tended to attribute success in mathematics to having 'inherited mathematical ability'. Consequently, many of them believed that mathematics is only for the clever ones. They also did not seem to take difficulty in mathematics as a challenge. Instead many of them seemed to give up easily, and felt frustrated and bored when they met with failures in mathematics. Of course, a word of caution is needed here, for these differences might be argued to be due to the difference in cultural presuppositions between the two countries, and not specifically a function of the mathematics learning experiences.

However, this finding of effort rather than ability as the source of success in mathematics is consistent with similar findings in other cross-cultural studies of oriental subjects (e.g., Stigler, & Perry,1988; Stevenson, & Lee; 1990; Cai, 1995; Huang & Waxman, 1997). Although a few recent studies (e.g Gipps & Tunstall, 1998; Elliot, Hufton, Hildreth & Illushin, 1999) have indicated an opposite trend, whereby effort rather than ability has been quoted as major reason for success in mathematics (Gipps & Tunstall, 1998) and in school work (Elliot et al., 1999) by the English young children. Perhaps the findings of this study suggest that at least for these samples of students and teachers (UK and Malaysia), the attribution of ability as a source of success in mathematics by the Anglo-Saxons, and the attribution of effort as its source by the Orientals, may still hold true for the adult members.

In addition, a comparison between different gender, age and occupational groupings highlighted some differences as well as similarities between the subgroups. In particular, the overall findings challenge the widespread claim in research literature that women exhibit more negative images of mathematics than men. In this study, there were no marked differences between the genders in reported liking and in images of mathematics, although the female respondents were inclined to display stronger negative feelings towards the learning of mathematics in school than their counterparts. The other difference between the two genders was that women respondents tended to attribute failure in mathematics to their own lack of mathematical ability while the men respondents tend to attribute the causes of their failure in mathematics to others (in particular, their mathematics teachers). Thus there are some similarities with traditional gender self-perceptions with regard to mathematics. Studies on children's perceived confidence in learning mathematics (e.g. Vermeer, Boekaerts and Seegers, 1997; Burton, 1989) suggest that boys generally exhibit higher confidence in their own mathematical abilities then girls do. A review by Gutbezahl (1995) also suggests that girls more than boys are likely to believe that mathematical ability is something that one either has or does not have. Implicitly, finding of this study suggests that for some respondents in this study, the difference in self-perception to mathematical ability between genders seem to persist even at later ages of life. This is consistent with the different patterns of attribution for success in mathematics across the genders discussed in Chapter 2.

Among the age groups, the young people aged between 17-20 years old seem to display the most negative images of mathematics. 40% of them reported a dislike of mathematics and 38% of them responded that they were or had been bored by mathematics. They tended to believe that mathematics is only for the clever ones and they themselves were lacking in this mathematical ability. In spite of the limitation in generalising as a result of opportunity sampling, the sample size of this age group was moderately large (n=100). Thus, this finding gives rise to concern as this age group has benefited from all of the most recent innovations and improvement in education and yet had these strong negative reactions.

In terms of occupational groupings, the results were not surprising because the mathematics teachers and the professionals were the groups which show the most positive images of mathematics, while the non-mathematics students and the lower social class (by occupation) were showed the least positive images of mathematics. Implicitly, these results suggest that higher mathematics qualifications and more involvement with mathematics might have some impact on people's images of mathematics.

In conclusion, many findings of this study were not surprising. In particular, many respondents' images of mathematics seem to be linked to their experiences of learning mathematics in school. Moreover, the possible factor of influence on the respondents' liking or disliking of mathematics seems to be linked to certain known factors (such as mathematics teachers and parents). Likewise, cultural differences in attribution for success in mathematics across the UK and Malaysian samples were also consistent with several previous cross-cultural studies on the same issue.

However, the main contribution of this thesis is to provide what is to my knowledge, the first study of the images of mathematics of the adult public. In addition, the causes and attributions of the views and images were also investigated for the first time.

The findings of this study, although limited and inconclusive, highlight the wide range of images of mathematics of a sample of the British adult public. Note that the sample of this study also includes the general public, and not just those who involved in education as many other studies do. In addition, the rich variety of images in the form of metaphors, and other verbal representations have illustrated the possible use of metaphors analysis, as a mean to gain a better insight and understanding into people's conceptions, views, feelings, and their experiences related to mathematics education. This study also illustrates the benefit of integrating both quantitative and qualitative methods as a way of comprehending and analysing a large data set.

Therefore, despite its limitations and weaknesses, this study may help to add on the existing knowledge and literature, as well as providing suggestions for further research, particularly with regard to study on adult's images of mathematics.

9.3 Recommendations for future research

Although this study has illuminated some interesting findings with regard to a sample of the adult public's images of mathematics and some possible factors of influence, it is still very limited in its generalisability and representativeness. Therefore, I recommend that future research to include a larger and more fully representative sample, which covers a wider range of adult members of the public in terms of gender, age, and occupation groupings. A larger and properly stratified sample drawn from around the UK would be necessary for full generalisation.

To conduct a survey on such a large sample, a questionnaire design is probably the most feasible method. However, given the limitations and possible pitfalls of a questionnaire that I have discussed earlier, great care would need to be taken in designing it. It is important to ensure that all the questions are as clear and explicit as possible, so as to eliminate ambiguity (especially words such as 'mathematics ' and 'image'), for these are weaknesses that have bedevilled the present study.

In this study, because of the large sample size, I opted to quantify my data. Although quantifying the data helps to give an overview picture, it is limited in depth. Therefore, to gain a better access to the public's affective (such as feelings and emotion) and cognitive aspects of the public's images of mathematics and the possible underlying factors, I suggest that future research of this type should also include more in-depth study using qualitative approaches. These approaches may include intensive, simulated recall interview in an informal setting, case study and life history, and followed by a systematic qualitative analysis in order to examine the issues proposed above.

Furthermore, the results of this study suggest that there are some striking differences in images of mathematics between the UK and Malaysian teacher and student samples. This suggests that cultural difference in beliefs about mathematics and values of mathematics might have influenced people's images of mathematics. However, these findings were limited in representativeness, therefore to confirm whether there really are cultural differences, I suggest that more international comparison studies are needed. Although there is an increasing literature on cross-cultural studies, most of these studies have focused on cross-cultural differences in students' mathematics achievement. Thus, I suggest that future cross-cultural studies could usefully to include comparisons in public images of mathematics between different countries.

Next, findings of this study show that the UK young non-mathematics students are the group that expressed the most negative images of mathematics. These findings are disturbing and cause for concern. Therefore, further in-depth study is needed to see if these results are widespread, and if so to examine and identify the underlying factors that might have resulted in the negative images of mathematics of this particular group.

Similarly, in this study, mathematics teachers were quoted as the major factor of influence in the respondents' images of mathematics. This finding highlighted the important role of mathematics teachers in mathematics education. Although there is increasing attention given to research on teachers' beliefs of mathematics and mathematics teaching, research studies into teachers' images of mathematics are still relatively limited. Thus, I suggest further research investigate teachers' images of mathematics and if they are coherent and consistent with the intended images of mathematics embodied in the planned curriculum.

9.4 Personal reflections

Academically, I have enhanced my knowledge about research in mathematics education and research methods. I profited from reading and utilising the wide range of research literature in mathematics education that I have been exposed to, but I have also learned that there is much more research to be done in mathematics education. In particular, this includes the integration of both affective and cognitive aspect of mathematics education, as well as the vast area of research in cross-cultural studies in mathematics learning and teaching.

I acknowledge that coming from a scientific paradigm background, it was difficult for me not to analyse my data using a quantitative approach. When I first started to analyse the open-ended questions, it was a real struggle for me. I found it hard to analyse the data qualitatively. I attempted to quantify my data and to present it in a neat and orderly manner. Now, upon reflection, I realise that deep in my mind, I strongly held an absolutist view of knowledge. Even though I know that the data consists of responses, which are people's opinions, subconsciously I believed that there were measurable realities behind these appearances. I was constantly seeking a standard or an objective list of categories that underlying the data. It took me a long time to analyse these open-ended data because I was struggling to free myself from this 'quantitative' frame of mind. Finally I managed to become comfortable with a qualitative frame of mind. From then on, I enjoyed very much analysing my interview data, which were mainly qualitative data in a more open manner. I believe I will be able to handle both quantitative and qualitative data comfortably and confidently. For me, this was the most valuable lesson. In addition, I learnt that there are many advantages in integrating both qualitative and quantitative methods in the analysis of data because they add strength and clarity in presentation of the data analysis.

During the process of analysing my data, I learnt about the difficulty and complexity in the interpretation of the responses given. This was particularly so when I was analysing the responses to open-ended questions and the interview data. While I was excited and enjoyed myself with the variety, richness and creativity shown in the data, I was also anxious and at times, frustrated in trying hard to get meanings out of these responses. I was concerned that I had not misinterpreted these responses. Especially for those responses given in metaphoric form, I was constantly aware that these metaphors might have meant differently to different people and in different situations. Moreover, as a researcher, I inevitably might bring in my personal values, preferences and bias into these interpretations, no matter how conscious I was. Thus, I learnt that one way of improving the validity and rigour of any research study is by triangulation of both methods and researchers.

My next major challenge was when I was writing up my thesis. English is not my mother tongue, which is Chinese, and is not even my second language, which is Malay, but is a third language for me. Besides struggling to find the right vocabulary to express myself, I find myself having problems in articulating and presenting my thought in a clear and critical manner. I have found that writing in English has helped me to clarify my thoughts and organise my thinking. Another important thing that I have learnt from writing up my thesis is that patience, effort and perseverance are more important than anything else.

In terms of personal growth, I have learnt a lot more about western culture and western values. As I was born and brought up in a typical Chinese family and coming from an eastern country (Malaysia), I brought with me my own set of cultural values and expectations. It was initially a culture shock for me to notice that there are great differences between Eastern and Western countries, particularly in terms of communalism and individualism. I was brought up to respect the elder and the authority, to seek for absolute truth and to be co-operative. I notice a very different focus of individualism here in Britain and the West, which emphasises 'individual independence', respect for individual privacy, and the acceptance of 'individual difference'. I also observed that the differences in these cultural values have resulted in differences in the handling of personal relationships and attitudes towards life and research.

Initially, I had a problem accepting the view that there is no 'the right way' and 'everyone is right in his or her own way'. I was very uncomfortable with these feelings of uncertainty and flexibility, but now I have learnt to enjoy these as a way of life. I realised that the attitudes of accepting individual differences and flexibility are very much needed in doing a good piece of research. I believe this is particularly important in educational research, which often involve personal contact and human relationships.

Obviously, during the process of researching, my personal image of mathematics has evolved. Initially, I loved mathematics for its absolutist truth and for it power of certainty. I enjoy solving mathematical problems and I appreciate its beauty, especially in the form of geometrical harmony. But now I have adopted a more fallibilist view of mathematical knowledge. I appreciate its social applications and I acknowledge its fallibility and limitations too. I believe that with this change of view I have understood mathematics better and in a different way. This is important because as a mathematics educator myself, I need to be able to understand the different views of mathematics that others have, in order to promote a positive image of mathematics of my students.

To conclude, during this research journey too, I have learnt to make decisions independently, and I learnt that there is no always a right or wrong way for everything. Consequently I have gained myself much more self-confidence about my own ability and my own decision-making. However, I aware that as I reach the end of this research journey, it marks the beginning of my next research journey.

Adult Literacy and Basic Skills Unit [ALBSU]. (1987). *Literacy, numeracy and adults: evidence from the National Child Development Study*. London: ALBSU.

Advisory Council for Adult and Continuing Education (ACACE). (1982). *Adult's mathematical ability and performance*. Leicester: ACACE.

Ahmed, A. and Williams, H. (1997). Numeracy project: A catalyst for teacher development and teachers researching. *Teacher Development, 1*(3), 357-373.

Aiken, L. R. (1970). Attitudes toward mathematics. *Review of Educational Research, 40*(4), 551-596.

Aiken, L. R. (1976). Update on attitudes and other affective variables in learning mathematics. *Review of Educational Research, 46*(2), 293-311.

Aiken, L. R., Jr. (1974). Two scales of attitude towards mathematics. *Journal for Research in Mathematics Education, 5*(1), 67-71.

Allen, B., & Shiu, C. (1997). 'Learning mathematics is like ...' - View of tutors and students beginning a distance-taught undergraduate course. In *Proceedings of the BSRLM Day Conferences* held at University of Nottingham (1 March 1997) and at University of Oxford (7 June 1997), pp.8-11.

American Association for the Advancement of Science (AAAS). (1989). *Science for all Americans: A project 2061 report on literacy goals in Science, mathematics and technology*. Washington, D.C: AAAS.

Askew, M., & William, D. (1995). *Recent research in mathematics education 5-16*. London: OFSTED.

Assessment of Performance Unit [APU]. (1988). *Attitudes and gender differences*. England: NFER-NELSON.

Assessment of Performance Unit [APU]. (1991). *APU Mathematics Monitoring (Phase 2)*, Slough: National Foundation for Educational Research.

Bajah, S. T. (1993). *Shortage of science and mathematics teachers: A Nigerian case study*. Abstract in ERIC documents. ED389688. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi>

Basic Skill Agency. (1997). *International numeracy survey: A comparison of the basic skills of adults 16-60 in seven countries*. London: Basic Skill Agency.

Battista, M. T. (1986). The relationship of mathematics anxiety and mathematical knowledge to the learning of mathematical pedagogy by preservice elementary teachers. *School Science and Mathematics, 86*(1), 10-19.

Beal, J. L., et al. (1985). *A study of incentive programs for mathematics and science teachers in the fifty states and District of Columbia, 1983-1985*. Abstract in ERIC documents. ED258823. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi>

Beaton, A. E., Mullis, I. V., Marton, M. O., Gonzalez, E. J., Kelly, E. J., & Smith, T. A. (1996). *Mathematics achievement in the middle school years: IEA's third international mathematics and science study (TIMSS).* Boston: Boston College.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice and mind*. New York: Basic Books Inc. Publishers.

Bell, A. (1989). General mathematical process: Theory, practice and research. In C.A. Maher, G. A. Goldin, & R. B. Davis (Eds.), *Proceedings of the 11th annual meeting: North American Chapter of the International Group for the Psychology of Mathematics Education [PME-NA-11], New Brunswick, New Jersey, USA, Vol. 2*, 69-93.

Benn, R. (1994). Mathematics breaking down the barriers. In D. Cohen (Ed.), *ALM-1, Proceedings of the Inaugural Conference of Adults Learning Mathematics- A Research Forum* (pp.24-29). London: University of London.

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counselling Psychology, 25*, 441-448

Bishop, A. J. (1988). *Mathematics enculturation: A cultural perspective on mathematics education.* Dordrecht: Kluwer Academic Publishers.

Bishop, A. J. (1996, July). *Values education in mathematics classrooms*. Paper presented at Working Group 22, 8th International Congress on Mathematical Education, Seville, Spain.

Branco, I., & Oliveira, I. (1996). Teachers' and students' images about learning mathematics. In L. Puig and A. Gutierrez (Eds.), *Proceedings of the 20th International Conference for the Psychology of Mathematics Education, Valencia, Spain, July 8-12, 1996, 1*-159.

Brookhart, S. M., & Freeman, D. J. (1992). Characteristics of entering teachers candidates. *Review of Educational Research, 62*, 37-60.

Brown, C. A., Carpenter, T. P., Kouba, V. L., Lindquist, M. M., Silver, E. A., & Swafford, J. O. (1988). Secondary school results for the Fourth NAEP Mathematics Assessment: Algebra, geometry, mathematical methods, and attitudes. *Mathematics Teacher, 81*, 337-347, 397.

Brown, L. (1992). The influence of teachers on children's image of mathematics. *For the Learning of Mathematics, 12*(2), 29-33.

Brown, L. (1995). The influence of teachers on children's image of mathematics. In L. Meira, and D. Carraher (Eds.), *Proceedings of the Nineteenth International Conference for the Psychology of Mathematics Education, Recife, Brazil, 2,* 146-153.

Brown, R., & Porter, T. (1993). *The methodology of mathematics*. <http://hydraulix.bangor.ac.uk/~mas010/public_html/methmat.html>

Bryman, A. (1988). *Quantity and quality in social research*. London: Unwin.

Bryman, A., & Cramer, D. (1990). *Quantitative data analysis for social scientists.* London: Routledge.

Bryman, A., & Cramer, D. (1997). *Quantitative data analysis with SPSS for Windows: A guide for social scientists.* London: Routledge.

Buerk, D. (1982). An experience with some able women who avoid mathematics. *For The Leaning of Mathematics, 3*(2), 19-24.

Bullough, R. V. (1991). Exploring personal teaching metaphors in preservice teacher education. *Journal of Teacher Education, 42*(1), 43-51.

Burghes, D. (1996). Why we lag behind in maths. *TESNET - The Times Educational Supplement* (15 March 1996). <http://www.tes.co.uk:8484/>

Burke, K. (1995) *An investigation of attitudes to mathematics among adult returners to education.* Unpublished M.Ed. assignment, University of Exeter.

Burton, L. (1987). From failure to success: Changing the experience of adult learners of mathematics. *Educational Studies in Mathematics, 18*(3), 305-316.

Burton, L. (1989). Images of mathematics. In P. Ernest (Ed.), *Mathematics teaching: the state of the art* (pp.180-187). New York: The Falmer Press.

Burton, L. (1997, December). *Mathematics: Communities of practices?* Paper presented at a meeting of the Research into Social Perspectives on Mathematics Education Group, London.

Buxton, L. (1981). *Do you panic about maths? Coping with maths anxiety.* London: Heinemann Educational Books.

Cai, J., Moyer, J. C. and Wang, N. (1997). *Parental roles in students' learning of mathematics*. Abstract in ERIC documents. ED412087. http://www.bids.ac.uk/ovidweb/ovidweb.cgi

Cai, Jinfa. (1995). A cognitive analysis of U.S. and Chinese students' mathematical performance on tasks involving computation, simple problem solving, and complex problem solving. *Journal for Research in Mathematics Education Monograph, No. 7.* USA: NCTM.

Cain-Caston, M. (1986). *Parent and student attitudes towards mathematics as they relate to third grade mathematics achievement*. Abstract in ERIC documents. ED334078. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi>

Calderhead, J., & Robson, M. (1991). Images of teaching: Student teachers' early conceptions of classroom practice. *Teaching and Teacher Education, 7*(1), 1-8.

Carter, G. and Norwood, K. S. (1997). The relationship between teacher and student belief about mathematics. *School Science and Mathematics, 97*(2), 62-67.

César, M. (1995). Pupils' ideas about mathematics. In L. Meira & D. Carraher (Eds.), *Proceedings of the 19th Conference of the International Group for the Psychology of Mathematics Education*, Recife, Brazil. 1-198.

Chen, Chuansheng., & Stevenson, H. W. (1995). Motivation and mathematics achievement: A comparative study of Asian-American, Caucasian-American, and East Asian high school students. *Child Development, 66*, 1215-1234.

Civil, M. (1990). "You only do math in math": A look at four prospective teachers' view about mathematics. *For the Learning of Mathematics, 10*(1), 7-9.

Clandinin, D. J. (1986). *Classroom practice: Teacher images in action.* London: The Falmer Press.

Clark, C. M., & Peterson, P. L. (1986). Teachers' thought processes. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp.255-296). New York: Macmillan.

Coben, D., & Chanda, N. (1997). Teaching 'not less than maths, but more': An overview of recent developments in adult numeracy teacher development in England, with a sidelong glance at Australia. *Teacher Development, 1*(3), 375-392.

Cockcroft Report.(1982). *Mathematics counts*: *Report of the Committee of Inquiry into the Teaching of Mathematics in Schools under the chairmanship of W. H. Cockcroft*. London: HMSO.

Cockcroft, W. (1994). Can the same mathematics program be suitable for all students? A personal view from Mathematics Counts, not forgetting standards. *Journal of Mathematical Behavior*, *13*(1), 37-51.

Cohen, L., & Manion, L. (1994). *Research methods in education* (4th ed.). London: Routledge.

Colombotos, J. (1965). The effect of personal vs. Telephone interviews on socially acceptable responses. *Public Opinion Quarterly, 29*, 457-458.

Colwell, D. (1998). Towards a theory of adults using mathematics: Time in everyday life. In A. Watson (Ed.), *Situated cognition and the learning of mathematics* (pp. 45-58). Oxford: Centre for Mathematics Education Research, University of Oxford Department of Educational Studies.

Coombs, L., & Freeman, R. (1964). Use of telephone interviews in a longitudinal fertility study. *Public Opinion Quarterly, 28*, 112-117.

Cooney, T. (1992, August). *Influencing secondary mathematics teachers' images of mathematics*. Paper presented at the 7th International Congress on Mathematical Education (ICME-7), Working Group 21: Public Images of mathematics, Quebec, Canada.

Cooney, T. J. (1985). A beginning teacher's view of problem solving. *Journal for Research in Mathematics Education, 16*, 324-336.

Cooney, T., Goffrey, F., Stephens, M., & Nickson, M. (1985). The professional life of teachers. *For the Learning of Mathematics, 5*(2), 24-30.

Copes, L. (1982). The Perry development scheme: A metaphor for learning and teaching mathematics. *For the Learning of Mathematics, 3*(1), 38-44.

Crawford, K., Gordon, S., Nicholas, J., & Prosser, M. (1993). Learning mathematics at university level: Initial conceptions of mathematics. In B. Atweh, C. Kanes, M. Carss, & G. Booker (Eds.), *Contexts in Mathematics education* (pp.209-214). Brisbane, Qld.: Mathematics Education Research Group of Australasia.

Cresswell, M. & Gubb, J. (1987). *The Second International Mathematics Study in England and Wales [SIMS]*. (International Studies in Pupils Performance Series).

Davis, P. J. and Hersh, R. (1983). *The mathematical experience*. Harmondsworth: Pelican Books.

De la Cruz & Thompson, V. (1992, August). *Influencing views of mathematics through the FAMILY MATH program*. Paper presented at 7th International Congress on Mathematical Education, Quebec 17-23 August 1992.

Deiner, C. I., & Dweck, C. S. (1978). An analysis of learned helplessness: Continuous changes in performance, strategy, and achievement motivation cognition following failure. *Journal of Personality and Social Psychology, 36*, 451-462.

Denzin, N. K. (1970). *The research act in sociology : A theoretical introduction to sociological methods*. London: Butterworth.

Department for Education and Employment [DfEE]. (1998a). *Numeracy matter: Strategy: The preliminary report of the Numeracy Task Force*. London: DfEE.

Department for Education and Employment [DfEE]. (1998b). *The implementation of the National Numeracy Strategy: The final report of the Numeracy Task Force*. Suffolk: DfEE.

Department of Education and Science. (1982). *Mathematics Counts* (The Cockcroft Report). London: HMSO.

Dew, K. M. H., Galassi, J. P., & Galassi, M. D. (1983). Mathematics anxiety: Some basic issues. *Journal of Counselling Psychology, 30*, 443-446.

Dick, T. P., & Rallis, S. F. (1991). Factors and influences on high school students' career choices. *Journal for Research in Mathematics Education, 22*(4), 281-292.

Dickens, M. N., & Cornell, D. G. (1990). *Parental influences on the mathematics self-concept of high-achieving adolescent girls*. AEL Minigrant Report No.20. Abstract in ERIC documents. ED318207. http://www.bids.ac.uk/ovidweb/ovidweb.cgi

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science.* Buckingham: Open University Press.

Durant, J. (1997). Editorial. *The Public Understanding of Science, 6*(4).

Durant, J. R., Evans, G. A., & Thomas, G. P. (1989). The Public understanding of science. *Nature, 340*, 11-14.

Eaton, M. J., & Dembo, M. H. (1997). Differences in the motivational beliefs of Asian American and non-Asian students. *Journal of Educational Psychology, 89*, 433-440.

Eccles, J., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993). Age and gender differences in children's self and task perceptions during elementary school. *Child Development, 64,* 830-847.

Economic Planning Unit (Malaysia). (1998). *The Malaysian economy in figures 1998: Chapter 2: Area, population, labour force and Quality of life.* Kuala Lumpur: The Prime Minister's Department <http://epu.jpm.my/publik/eco98/26.html>

Editorial (1997). *The International Journal of Science Education, 19*(10), 1115-1116.

Elbaz, F. L. (1983). *Teacher thinking: A study of practical knowledge*. London: Croom Helm.

Elliott, J., Hufton, N., Hildreth, A., & Illushin, L. (1999). Factors influencing educational motivation: A study of attitudes, expectations and behaviour of children in Sunderland, Kentucky and St Petersburg. *British Educational Research Journal, 25*(1), 75-94.

Ernest, P. (1988). The attitudes and practices of student teachers of primary school mathematics. In A. Borbas (Ed.), *Proceedings of 12th International Psychology of Mathematics Education Conference, Veszprem, Hungary: OOK, 1*, 288-295.

Ernest, P. (1989). The impact of beliefs on the teaching of mathematics. In C. Keitel, P. Damerow, A. Bishop & P. Gerdes (Eds.), *Mathematics, Education and Society* (pp.99-101). Paris: UNESCO Science and Technology Education Document Series, No.35.

Ernest, P. (1991). *The philosophy of mathematics education*. London: The Falmer Press.

Ernest, P. (1995). *The social context of mathematics and education*. Exeter, UK: School of Education, University of Exeter.

Ernest, P. (1995). Values, gender and images of mathematics: a philosophical perspective. *International Journal of Mathematics Education, Science and Technology, 26,* 3, 449-462.

Ernest, P. (1996). Popularization: myths, mass media and modernism. In A. J. Bishop (Ed.), *The International Handbook of Mathematics Education* (pp.785-817). Dordrecht: Kluwer Academic.

Evans, G., & Durant, J. (1995). The relationship between knowledge and attitudes in the public understanding of science in Britain. *The Public Understanding of Science, 4,* 57-74.

Evans, J. (1993). *Adults and numeracy*. Unpublished PhD thesis, University of London Library.

Evans, J. (1994). Quantitative and qualitative research methodologies: rivalry or co-operation? In J. Pedro da Ponte & J. Filipe Mato (Eds.), *Proceedings of the 18th Conference of the International Group for the Psychology of Mathematics Education*. Lisbon, Portugal, *2*, 320-327.

Feather, N. (Ed.). (1982). *Expectations and actions*. Hillsdale, NJ: Erlbaum.

Fennema, E., & Peterson, P. L. (1985). Autonomous learning behaviour: A possible explanation of gender-related differences in mathematics. In L. C. Wilkison, and C. B. Marrett (Eds.), *Gender-related differences in classroom interactions* (pp.17-35). Orlando, Florida: Academic Press.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitudes Scales: instruments designed to measure attitudes towards the learning of mathematics by females and males. *Journal for Research in Mathematics Education, 7*, 324-326.

Fennema, E., & Sherman, J. A. (1978). Sex-related differences in mathematics achievement and related factors: A further study. *Journal for Research in Mathematics Education, 9*, 189-203.

Fennema, E., Peterson, P. L., Carpenter, T. P., & Lubinski, C. A. (1990). Teachers' attributions and beliefs about girls, boys and mathematics. *Educational Studies in Mathematics, 21*(1), 55-69.

Filacek, A., & Krizova-Frýdová, E. (1994). The public image of science in the Czech and Slovak Republic. *The Public Understanding of Science, 3*, 83-97.

FitzSimon, G. E. (1993). Constructivism and the adult learner: Marieanne's story. In B. Atweh, C. Kanes, M. Carss, & G. Booker (Eds.), *Contexts in Mathematics edcuation* (pp.247-252). Brisbane, Qld.: Mathematics Education Research Group of Australasia.

FitzSimon, G. E. (1994a). TAFE students: The affective domain and mathematics. In G. Bell, B. Wright, N. Leeson, & J. Geake (Eds.), *Challenges in mathematics education: Constraints on construction* (233-241). Lismore, NSW: Mathematics Education Research Group of Australasia.

FitzSimon, G. E. (1994b). *Teaching mathematics to adults returning to study*. Geelong, Vic.: Deakin University.

Fitzsimons, G. E., Jungwirth, H., Maab, J. & Schloeglmann, W. (1996). Adults and mathematics (Adult numeracy). In A. J. Bishop (Ed.), *The International Handbook of Mathematics Education* (pp.755-784). Dordrecht: Kluwer Academic.

Frank, M. L. (1988). Problem solving and mathematical beliefs. *Arithmetic Teacher, 35*(5), 32-34.

Frank, M. L. (1990). What myths about mathematics are held and conveyed by teachers? *Arithmetic Teacher, 37*(5), 10-12.

Gal, I., & Schuh, A. (1994). *Who counts in adult literacy programs? A national survey of numeracy education*. Philadelphia: National Centre on Adult Literacy.

Galbraith, P. L., & Chant, D. (1993). The profession, the public, and school mathematics. In B. Atweh, C. Kanes, M. Carss, & G. Booker (Eds.), *Contexts in Mathematics edcuation* (pp.267-273). Brisbane, Qld.: Mathematics Edcuation Research Group of Australasia.

Giligan, C. (1982). *In a different voice: Psychological theory and women's development*. Cambridge, MA: Harvard University Press.

Gipps, C., & Tunstall, P. (1998). Effort, ability and the teacher: young children's explanation for success and failure. *Oxford Review of Education, 24*, 149-165.

Grier, S. (1994). The situatedness of adults' numerical understanding. In G. Bell, B. Wright, N. Leeson, & J. Geake (Eds.), *Challenges in mathematics education: Constraints and construction* (pp. 315-322). Lismore, NSW: Mathematics Education Research Group of Australasia.

Grigutsch, S. & Törner, G. (1998). *World views of mathematics held by university teachers of mathematics science*. Gesamthochschule, Duisburg: Gerhard Mercator Universitat.

Gross, A. (1994). The roles of rhetoric in the public understanding of science. *The Public Understanding of Science, 3*, 3-23.

Grouws, D. A. & Lembke, L. O. (1996). Influential factors in student motivation to learn mathematics: the teacher and classroom culture. In M. Carr (Ed.), *Motivation in mathematics* (pp.39-62). Cresskill, New Jersey: Hampton Press.

Groves, R. M., & Kahn, R. L. (1979). *Surveys by telephone: A national comparison with personal interviews.* New York: Academic Press.

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation.* Beverly Hills: Sage.

Gutbezahl, J. (1995). *How Negative Expectancies and Attitudes Undermine Females' Math Confidence and Performance: A Review of the Literature*. Abstract in ERIC documents. ED380279. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi>

Hammersley, M. (1991). *What's wrong with Ethnography?: Methodological explorations*. London: Routledge.

Handerson, D. (1981). Three papers. *For the Learning of Mathematics, 1*(3), 12-15.

Haris, S., Keys, W., & Fernandes, C. (1997). *Third International Mathematics and Science Study: Second National Report. Part 1:Achievement in mathematics and science at age 9 in England*. Slough: National Foundation for Educational Research.

Hendel, D. D. (1980). Experiential and affective correlates of math anxiety in adult women. *Psychology of Women Quarterly, 5*, 219-289.

Hersh, R. (1997). *What is mathematics, really?* London : Jonathan Cape.

Hilton, P., (1980) Math Anxiety: Some Suggested Causes And Cures, Part 1, *Two Year College Mathematics Journal*, Vol. 11, No. 3, pp. 174-188.

Horowitz, M. J. (1983). *Image formation and psychotherapy*. London: Jason Aronson.

Howe, K. R. (1988). Against the quantitative-qualitative incompatibility thesis, or dogmas die hard. *Educational Researcher, 11*, 10-16.

Howson, A. G., & Kahane, J. P. (Eds.). (1990). *The Popularization of Mathematics*. Cambridge: Cambridge University Press.

Hoyles, C. (1982). The pupils' view of mathematics learning. *Educational Studies in Mathematics, 13*, 349-372.

Huang, S. L., & Waxman, H. C. (1997). *Comparing Asian- and Anglo-American students' motivation and perceptions of the learning environment in mathematics.* Abstract in ERIC documents. ED359284. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi >

Husen, T. (Ed.). (1967). *International study of achievement in mathematics: A comparison of twelve countries*. Stockholm: Almqvist & Wiksell.

Irwin, A. (1996). Challenging images of science. *Studies in Science Education, 28*, 167-173.

Issacson, Z. (1989). Of course you could be an engineer, dear, but wouldn't you rather be a nurse or teacher or secretary? In P. Ernest (Ed.), *Mathematics teaching: the state of the art* (pp.188-194). New York: The Falmer Press.

Jacobsen, E. (1985). Reducing differences in mathematical expectations between boys and girls. *Studies in Mathematics Education, 4*. (cited in Burton, 1989).

Johnson, M. (1987). *The body in the mind: the bodily basis of meaning, imagination, and reason.* Chicago: The University of Chicago Press.

Kelly, L., & Olham, E. (1992, August). *Images of mathematics among teachers: Perceptions, beliefs and attitudes of primary teachers and student teachers in the Republic of Ireland*. Paper presented at the 7th International Congress on Mathematical Education (ICME-7), Working Group 21: Public Images of mathematics, Quebec, Canada.

Kerlinger, F. N. (1986). *Foundations of behavioral research* (3rd ed.). New York: Holt, Rinehart and Winston.

Keys, W., Haris, S., & Fernandes, C. (1996a). *Third International Mathematics and Science Study: First National Report. Part 1: Achievement in mathematics and science at age 13 in England.* Slough: National Foundation for Educational Research.

Keys, W., Haris, S., & Fernandes, C. (1997). *Third International Mathematics and Science Study: First National Report. Part 2.* Slough: National Foundation for Educational Research.

Keys, W., Harris, S., & Fernandes, C. (1996b). *Third International math and Science Study [TIMSS]: First national Report, Part 1*. Berkshire: NFER-NELSON

Kloosterman, P. (1984, April,). *Attribution theory and mathematics education*. Paper presented at the 68th Annual Meeting of the American Educational Research Association, New Orleans, L.A.

Kloosterman, P. (1996). Students' beliefs about knowing and learning mathematics: Implication for motivation. In M. Carr (Ed.), *Motivation in mathematics* (pp.131-156). Cresskill, New Jersey: Hampton Press.

Kloz, G. (1996). *An introduction to Public understanding of mathematics*. (Articles on Public Understanding of Math). <http://forum.swarthmore.edu/social/perception.intro.html>

Knudtzon, S. H. (1996). Student teachers' understanding of mathematics education. In L. Puig and A. Gutierrez (Eds.), *Proceedings of the 20th International conference for the Psychology of Mathematics Education,* Valencia, Spain, July 8-12, 1996, 1-181.

Knudtzon, S. H. (1997). Student teachers' pictures of teaching and learning. In E. Pehkonen (Ed.), *Proceedings of the 21st conference of the International Group for the Psychology of Mathematics Education*. Lahti, Finland: University of Helsinki, Lahti Research and Training Centre, *1*-287.

Kogelman, S., & Warren, J. (1978). *Mind over math*. New York: McGraw-Hill.

Kosslyn, S. M. (1980). *Image and mind*. Cambridge, Mass.: Harvard University Press.

Kulm, G. (1980). Research on mathematics attitude. In R. J. Shunway (Ed.), *Research in mathematics education* (pp.356-387). Reston, VA: National Council of Teachers of Mathematics.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.

Lang, S. (1984). *The beauty of doing mathematics: three public dialogues*. New York: Springer-Verlag.

Lavrakas, P. J. (1993). *Telephone survey methods: Sampling, selection, and supervision*. London: Sage.

Leder, G. C. (1987). Attitudes towards mathematics. In T. A. Romberg, & D. M. Stewart (Eds.), *The monitoring of school mathematics* (vol. 2, pp.261-277). Madison: Wisconsin Centre for Education Research.

Leder, G. C. (1992a). Measuring attitudes to mathematics. In W. Geeslin, & K. Graham (Eds.), *Proceedings of the 16th Conference of the International Group for the Psychology of Mathematics Education*. University of New Hampshire, Durham, USA, 2, 33-39.

Leder, G. C. (1992b). Mathematics and gender: Changing perspectives. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp.597-622). New York: Macmillan.

LeDoux, J. (1998). *The emotional brain*. London: Weidenfeld and Nicholson.

Lee, Molly., Yoong, Suan., Loo, Seng Piew., Khalid, Khadijah., Ghazali, Munirah., & Lim, Chap Sam. (1996). *Students' orientation towards science and mathematics: Why are enrolments falling?* (Monograph series number 1/96). Penang, Malaysia: Universiti Sains Malaysia.

Lerman, S. (1992). Learning mathematics as a revolutionary activity. In M. Nickson, & S. Lerman (Eds.), *The social context of mathematics education: Theory and practice* (pp.170-179). London: South Bank Press.

Lerman, S. (1993). The role of the teacher in children's learning of mathematics. In A. Bishop, K. Hart, S. Lerman and T. Nunes (Eds.), *Significant influences on children's learning of mathematics*, (pp. 61-86). Paris: UNESCO Science and Technology Education Document Series, No.47.

Leu, Yuh-Chyn.(1998, July). *Values in an elementary mathematics classroom in Taiwan*. Paper presented at the 22th Conference of the International Group for the Psychology of Mathematics Education, Working Group 4: Cultural aspect of mathematics at University of Stellenbosch, South Africa.

Lim, Chap Sam & P. Ernest (1997). Values in mathematics education: what is planned and what is espoused? In British Society for Research into Learning Mathematics (BSRLM), *Proceedings of the Day Conference* held at University of Nottingham, 1 March 1997. (pp.37-44).

Lin, F. L., Huang, M. F., & Chu, T. C. (1992, August). *The influence of examination in shaping students' images of mathematics.* Paper presented at the 7th International Congress on Mathematical Education (ICME-7), Working Group 21: Public Images of mathematics, Quebec, Canada.

Lin, Fou-Lai, & Chin, Chien. (1998, July). *Study on values in mathematics education in Taiwan*. Paper presented at the 22th Conference of the International Group for the Psychology of Mathematics Education, Working Group 4: Cultural aspect of mathematics at University of Stellenbosch, South Africa.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills: Sage.

Llabre, M., & Suarez, E. (1985). Predicting Math Anxiety and Course Performance In College Women and Men. *Journal of Counselling Psychology, 32*, 283-287.

Long, M., & Steinke, J. (1996). The thrill of everyday science: Images of science and scientists on children's educational science programme in the United States. *The Public Understanding of Science, 5*(2), 101-119.

Lucas, W. A., & Adams, W. C. (1977). *An assessment of telephone survey methods*. Santa Monica, California: The Rand Corporation.

Ma, X., & Kishor, N. (1997). Assessing the relationships between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education, 28*(1), 26-47.

Malaysian Ministry of Education. (1982). *Educational Statistics of Malaysia 1976-1979*. (p.43). KL: Educational Planning & Research Division.

Malaysian Ministry of Education. (1996). *Educational Statistics of Malaysia*. (p. 9). KL: Educational Planning & Research Division.

Martins, I., & Ogborn, J. (1997). Metaphorical reasoning about genetics. *International Journal of Science Education, 19*(1), 47-63.

Maxwell, J. (1989). Mathephobia. In P. Ernest (Ed.), *Mathematics Teaching: The State of the Art* (pp.221-226). London: Falmer Press.

McLean, L., Wolfe, R., & Wahlstrom, M. (1987). *Learning about teaching from comparative studies: Ontario mathematics in International perspectives*. Ontario: Ministry of Education.

McLeod, D. B. (1992). Research on affect in mathematics education: A conceptualisation. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp.575-596). New York: Macmillan.

McLeod, D. B. (1994). Research on affect and mathematics learning in the JRME: 1970 to the present. *Journal for Research in Mathematics Education, 25*(6), 634-647.

McLeod, D. B., & Ortega, M. (1993). Affective issues in mathematics education. In P. S. Wilson (Ed.), *Research ideas for the classroom: high school mathematics* (pp.21-36). New York: Macmillan.

McLeod, W. T. (Ed.). (1987). *The new Collins dictionary and thesaurus in one volume.* UK: HarperCollins.

McSheffrey, K. (1992). *Mathematics experiences of women and girls: A narrative inquiry*. Abstract in ERIC documents. ED355118. http://www.bids.ac.uk/ovidweb/ovidweb.cgi

Merttens, R., & Vass, J. (Eds.). (1993). *Partnerships in maths: Parents and schools The IMPACT Project*. London: Falmer Press.

Miles, M. B., & A. M. Huberman (1994). *Qualitative data analysis: An expanded sourcebook* (2nd Edition). Thousand Oaks, California: Sage.

Millar, R. (1989). Introduction: Science education and science studies. In R. Millar (Ed.), *Doing science: Images of science in science education* (pp.1-9). London: The Falmer Press.

Millar, R., & Wynne, B. (1988). Public understanding of science: From contents to process. *International Journal of Science Education, 10*(4), 388-98.

Miller, C. (1995). In-depth interviewing by telephone: some practical considerations. *Evaluation and Research in Education, 9*(1), 29-38.

Minato, S., & Kamada, T. (1996). Results of research studies on causal predominance between achievement and attitude in junior high school mathematics of Japan. *Journal for Research in Mathematics Education, 27*(1), 96-99.

Moreira, C. (1991). Teachers' attitudes towards mathematics and mathematics teaching: perspectives across two countries. *Proceedings of the 15th Conference of the International Group for the Psychology of Mathematics Education, Assisi, Italy, 3,* 17-24.

Morris, J. (1981). Math anxiety: Teaching to avoid it. *Mathematics Teacher, 74*(6), 413-417

Mtetwa, D., & Garofalo, J. (1989). Beliefs about mathematics: An overlooked aspect of student difficulties. *Academic Therapy, 24*(5), 611-618

Munby, H. (1984). A qualitative approach to the study of a teacher's beliefs. *Journal of Research in Science Teaching, 21*, 27-38.

Munby, H. (1986). Metaphor in the thinking of teachers: An exploratory study. *Journal of Curriculum Studies, 18*(2), 197-209.

Mura, R. (1992, August). *Images of mathematics held by mathematicians*. Paper presented at the 7th International Congress on Mathematical Education (ICME-7), Working Group 21: Public Images of mathematics, Quebec, Canada.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: NCTM.

National Curriculum Council. (1989). *Non-Statutory Guidance in Mathematics.* London: Her Majesty's Stationery Office.

National Research Council. (1989). *Everybody counts: a report to the nation on the future of mathematics education.* Washington, D.C: National Academy Press.

National Science Board. (1981). *Science Indicators - 1980*. Washington D. C.: Government Printing Office.

National Science Board. (1983). *Science Indicators - 1982*. Washington D. C.: Government Printing Office.

National Science Board. (1985). *Science Indicators - 1985*. Washington D. C.: Government Printing Office.

National Science Board. (1988). *Science and Engineering Indicators - 1987*. Washington D. C.: Government Printing Office.

Neale, D.C. (1969). The role of attitudes in learning mathematics. *Arithmetic Teacher, 16*, 631-640.

Neuman, D. (1995). What is the motive of mathematics education? In L. Meira, & D. Carraher (Eds.), *Proceedings of the 19th International Conference for the Psychology of Mathematics Education, Recife, Brazil, 3*, 248-255.

Nias, J. (1991). Primary teacher talking. In G. Walford (Ed.), *Doing educational research* (pp. 147-165). London: Routledge.

Niaz, M. (1997). Can we integrate qualitative and quantitative research in science education? *Science and Education, 6*(3), 291-300.

NISTEP. (1994). *Science and Technology Indicators*. Tokyo: NISTEP.

Office of Population and Census and Surveys; and Employment Department Group (1990a). *Standard Occupation Classification, Volume 1: Structure of the classification*. London: HMSO.

Office of Population and Census and Surveys, and Employment Department Group (1990b). *Standard Occupation Classification, Volume* 2: Coding Index. London: HMSO.

Office of Population and Census and Surveys, and Employment Department Group (1990c). *Standard Occupation Classification, Volume 3*. London: HMSO.

Office of Population Census and Surveys. (1993). *1991 Census Report for Great Britain: Part II*. London: HMSO.

Ortony, A. (Ed.). (1979). *Metaphor and thought*. Cambridge: Cambridge University Press.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Parsons, J. E., Alder, T. F., & Kaczala, C. M. (1982). Socialization of achievement attitudes and beliefs: Parental influences. *Child Development, 53*, 310-321.

Paulos, J. A. (1992). Mathematics-moron myths. *Mathematics Teacher, 85*(5), 335.

Pearson, G., Pringle, S. M., & Thomas, J. N. (1997). Scientists and the public understanding of science. *The Public Understanding of Science, 6*(3), 279-289.

Pedersen, K., Elmore, P., & Bleyer, D. (1986). Parent attitude and student career interests in junior high school. *Journal for Research in Mathematics Education, 17*(1), 49-59.

Pehkonen, E. & Törner, G. (1996). Mathematical beliefs and different aspects of their meaning. *Zentralblatt für Didaktik der Matematik (ZDM), 4*, 101-108. (International Reviews on Mathematics Education).

Perry, W. G., Jr. (1981). Cognitive and ethnical growth: The making of meaning. In A. Chickering (Ed.), *The modern American college* (pp.76-116). San Francisco: Jossey-Bass.

Perry, W.G., Jr. (1970). *Forms of intellectual and ethical development in the college year: A scheme*. New York: Holt, Rinehart & Winston.

Peterson, I. (1996). *Searching for new mathematics*. (Articles on Public Understanding of Math). <http://forum.swarthmore.edu/social/articles/ivars.html>

Petkova, K., & Boyadjieva, P. (1994). The image of the scientist and its functions. *The Public Understanding of Science, 3*(2), 215-224.

Pimm, D. (1981). Metaphor and analogy in mathematics. *For the Learning of Mathematics, 1* (3), 47-50.

Pimm, D. (1987). *Speaking mathematically*. New York: Routledge and Kegal, Paul.

Porkess, R. (1995). Maths report has its minus points. *TESNET - The Times Educational Supplement* (1 December 1995). <http://www.tes.co.uk:8484/>

Q.S.R. NUD*IST (Non-numerical Unstructured Data Indexing Searching and Theorizing). (1994). *Qualitative data analysis software for research professionals: User guide. Revision 3.0*. California: Qualitative Solutions and Research Pty. Ltd.

Quinn, B., & Jadav, A. D. (1987). Causal relationship between attitude and achievement for elementary grade mathematics and reading. *Journal of Educational Research, 80*, 366-372.

Random House Webster's Unabridged Electronic Dictionary (1996). Random House, Inc.

Raymond, A. M. (1993). *Unravelling the Relationships between Beginning Elementary Teachers' Mathematics Beliefs and Teaching Practices*. Abstract in ERIC documents. ED390694. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi >

Reilly, L. B. et al (1992). *Study to examine math anxiety for students who are single parents and those enrolled in non-traditional career preparation programs*. Abstract in ERIC documents. ED359380. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi >

Resnick, L. E., Viehe, J., & Segal, S. (1982). Is Mathematics Anxiety A Local Phenomenon? A Study of Prevalence and Dimensionality. *Journal of Counselling Psychology, 29*, 39-47

Reynolds, A. J., & Walberg, H. J. (1992). A process model of mathematics achievement and attitude. *Journal for Research in Mathematics Education, 23*(4), 306-328.

Reynolds, D., & Farrell, S. (1996). *World apart? A review of international surveys of educational achievement involving England*. London: HMSO.

Richardson, F. C., & Woolfolk, R. L. (1980). Mathematics anxiety. In I. G. Sarason (Ed.), *Test Anxiety: Theory, Research, and Applications* (pp. 271-278). Hillsdale, NJ: Erlbaum.

Robitaille, D. F., & Garden, R. A. (Eds.). (1989). *The IEA study of mathematics II: contexts and outcomes of school mathematics*. Oxford: Pergamon.

Rogers, L. (1992). Images, metaphors and intuitive ways of knowing: The contexts of learners, teachers and of mathematics. In F. Seeger, & H. Steinbring (Eds.), The dialogue between theory and practice in mathematics education: Overcoming the broadcast metaphor. *Proceedings of the Fourth Conference on Systematic Co-operation between Theory and Practice in Mathematics Education [SCTP],* Brakel, Germany, September 16-21, 1990.

Rogers, T. F. (1976). Interviews by telephone and in person: Quality of responses and field performance. *Public Opinion Quarterly, 40*, 51-65.

Rooney, J. (1998). Teaching influence on life-long perceptions of mathematics. *Teaching Mathematics and Its Applications, 17*(1), 12-18.

Ross, M., & Kamba, M. (1997). *The state of the arts: In five English secondary schools.* Exeter, UK: School of Education, University of Exeter.

Rounds, J. B., & Hendel, D. D. (1980). Mathematics anxiety and attitudes towards mathematics, measurement and evaluation. *Guidance, 13*, 83-89.

Royal Society. (1976). The training and professional life of teachers of mathematics. . London: The Royal Society.

Royal Society. (1985a). *The Public Understanding of Science*. London: The Royal Society.

Royal Society. (1985b). *Science is for everybody: Summary report*. London: The Royal Society.

Rupley, W. H., & Resek, D. (1980). Combating Mathophobia with a Conceptual Approach toward Mathematics. *Educational Studies in Mathematics, 11*(4), 423-441.

Ryckman, D. B., & Mizokawa, D. T. (1988). *Causal Attributions of academic success and failure: Asian Americans' and White Americans' beliefs about effort and ability. Abstract in ERIC documents. ED293967.* <http://www.bids.ac.uk/ovidweb/ovidweb.cgi>

Samimy, K., Liu, J., & Matsuta, K. (1994). Gambare, Amae, and Giri: A cultural explanation for Japanese children's success in mathematics. *Journal of Mathematical Behavior, 13*, 261-271.

Sandman, R. S. (1980). The mathematics attitude inventory: Instrument and user's manual. *Journal for Research in Mathematics Education, 23*, 306-328.

Schmiedeskamp, J. (1962). Reinterviewed by telephone. *Journal of marketing, 26*, 28-34.

Schoenfeld, A. H. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education, 20*, 338-355.

Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist, 26*, 207-231.

Sewell, B. (1981). *Use of mathematics by adults in daily life*. Leicester, UK: Advisory Council for Adult and Continuing Education (ACACE).

Sfard, A. (1994). Reification as the birth of metaphor. *For the Learning of Mathematics, 14* (1), 44-55.

Shuard, H. B. (1982). Differences in mathematical performance between girls and boys. In Cockcroft Report.(1982). *Mathematics counts*: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools under the chairmanship of W. H. Cockcroft (pp. 273-287). London: HMSO.

Singh, S. (1997). *Fermat's last theorem: the story of a riddle that confounded the world's greatest minds for 358 years*. London : Fourth Estate.

Skemp, R. R. (1976). Relational and instrumental understanding. *Mathematics Teaching, 77*, 20-26.

Skovsmose, O. (1994). *Towards a philosophy of critical mathematics education*. Netherland: Kluwer Academic Publishers.

Smith, H. W. (1975). *Strategies of social research: The methodological imagination*. London: Prentice-Hall.

Song, M. J. & Ginsburg, H. P. (1987). The development of informal and formal mathematical thinking in Korean and U.S. children. *Child Development, 58*, 1286-1296.

Steinback, M., & Gwizdala, J. (1995). Gender differences in mathematics attitudes of secondary students. *School Science and Mathematics, 95*, 36-41.

Stevenson, H. W., & Lee, S. (1990). *Context of achievement: A study of American, Chinese, and Japanese children*. Chicago, IL: University of Chicago Press.

Stevenson, H. W., & Stigler, J. W. (1992). *The learning gap: Why our schools are failing and what we can from Japanese and Chinese children*. New York: Summit Books.

Stevenson, H. W., Chen, C., & Uttal, D. H. (1990). Beliefs and achievement: A study of black, Anglo and Hipanic children. *Child Development, 61*, 508-523.

Stigler J.W. and Baraness, R. (1988). Culture and mathematics learning. In Ernst, Z. Rothkorf (Ed.). *Review of Research in Education, v15*. Washington D.C.: American Educational Research Association.

Stigler, J. W. & Perry, M. (1988). Cross cultural studies of mathematics teaching and learning: Recent findings and new directions. In D.A. Grouws, & T. J. Cooney (Eds.), *Perspective on research on effective mathematics teaching* (pp. 194-223). Reston: NCTM.

Thompson, A. (1984). The relationship of teachers' conceptions mathematics teaching to instructional practice. *Educational Studies in Mathematics, 15*, 105-127.

Thompson, P. W. (1996a). Imagery and the development of mathematical reasoning. In L. P. Steffe, P. Nesher, P. Cobb, G. A. Goldin, & B. Creer (Eds.), *Theories of mathematical learning* (pp.267-283). Mahwah, New Jersey: Lawrence Erbaum Associates Publishers.

Thompson, P. W. (1996b). Notations, conventions, and constraints: Contribution to effective uses of concrete materials in elementary mathematics. *Journal for Research in Mathematics Education, 23*(2), 123-147.

Times Educational Supplement (TES). (September 12, 1997). *Thanks … but no thanks. [Extras and updates].* <http://www.tes.co.uk:8484/tp/9000000/PRN/network/library/library.html>

Times Educational Supplement (TES). (September 4, 1998). *Teacher shortage linked to pass rate fall. [News and opinion]*. <http://www.tes.co.uk:8484/>

Tobias, S. (1980). *Overcoming Math Anxiety*, Houghton-Mifflin: Boston

Tobias, S. (1987). Math Anxiety. *Science, 237*, 1556

Travers, K. J., & Westbury, I. (Eds.). (1989). *The IEA study of mathematics I: Analysis of mathematics curricula*. Oxford: Pergamon Press.

Tuckman, B. W. (1972). *Conducting educational research*. New York: Holt, Rienhart & Winston.

Vanayan, M., White, N., Yuen, P., & Teper, M. (1997). Beliefs and attitudes toward mathematics among third- and fifth-grade students: A descriptive study. *School Science and Mathematics, 97*(7), 345-351.

Vermeer, H., Boekaerts, M., & Seegers, G. (1997). Gender differences in cognitive and affective variables during two types of mathematics tasks. In E. Pehkonen (Ed.), *Proceedings of the 21th International Conference for the Psychology of Mathematics Education, Lahti, Finland, 4*, 262-269.

Weiner, B. (1983). Some thoughts about feelings. In S. G. Paris, G. M. Olson, & H. W. Stevenson (Eds.), *Learning and motivation in the classroom* (pp. 165-178). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Weiner, B. (1986). *An attributional theory of motivation and emotion*. New York: Springer-Verlag.

Weiner, B., Russell, D., & Lerman, D. (1978). Affective consequences of causal ascriptions. In J. H. Harvey, W. J. Ickes, & R. F. Kidds (Eds.), *New directions in attribution research* (Vol. 2). Hillsdale, NJ: Lawrence Erlbaum Associates.

Weiner, B., Russell, D., & Lerman, D. (1979). The cognition-emotion process in achievement-related contexts. *Journal of Personality and Social Psychology, 37*, 1211-1220.

Wigfield, A. (1983). *Students' perceptions of their parents' beliefs concerning their academic competence.* Abstract in ERIC documents. ED235926. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi >

Wilson, M. R. (1992, August). *Prospective secondary teachers' images of mathematics, mathematics teaching and mathematical functions.* Paper presented at the 7th International Congress on Mathematical Education, Working Group 21: Public Images of mathematics, Quebec, Canada.

Wiseman, F. (1972). Methodological bias in public opinion surveys. *Public Opinion Quarterly, 34*, 105-108.

Wood, L. N., & Smith, N. F. (1993). Students' ideas about mathematics. In B. Atweh, C. Kanes, M. Carss, & G. Booker (Eds.), *Contexts in Mathematics edcuation* (pp.593-597). Brisbane, Qld.: Mathematics Education Research Group of Australasia.

Yee, D. K. et al (1984). *The relationship of family environments to parent motivation strategies and children's self-consciousness in the mathematics classroom*. Abstract in ERIC documents. ED250157. <http://www.bids.ac.uk/ovidweb/ovidweb.cgi >

Yee, D. K. et al (1986). *Sex equity in the home: Parents' influence on their children's attitudes about math.* Abstract in ERIC documents. ED280717 <http://www.bids.ac.uk/ovidweb/ovidweb.cgi >

Zhang, D. Z., Liu, H. K., & Yu, S. (1990). Some aspects of the popularization of mathematics in China. In A. G. Howson, & J. P. Kahane (Eds.), *The Popularization of Mathematics* (pp. 207-210). Cambridge: Cambridge University Press.

Zhang, Z., & Zhang, J. (1993). A survey of public scientific literacy in China. *The Public Understanding of Science*, *2*, 21-38.